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CONCRETE SHIPS

HISTORICAL NOTES CONCERNING THEM AND A DISCUSSION OF THE PROBLEMS INVOLVED IN THEIR CONSTRUCTION.

BY

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I HEREBY RECOMMEND THAT THE THESIS PREPARED BY

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PREFACE

During the first part of 1917, the need for more rapid construction of ships, due to the fact that our country had become engaged in the great war, induced the president of the Portland Cement Association, Mr. B. F. Affleck, to institute a research for all available information concerning the use of Portland cement concrete in ship construction. Previous to that time there had appeared no systematic collection of the scattered information concerning the use of this material. He realized this was the necessary first step to arouse interest in a material which he believed to be better adapted to the construction of ships than those in common use.

Mr. Affleck was also president of the Universal Portland Cement Company, so in order to speed the work he decided to make use of this company's Promotion Bureau in securing necessary data. In consequence it fell to the author's lot to prepare first of all an outline for a pamphlet; to gather the necessary information; and finally, because of experience gained in this work, to assist prospective builders of reinforced concrete vessels in the preparation of their designs.

Direct credit for the data that appears in this thesis is due therefore to Mr. Affleck, Portland Cement Association and Universal Portland Cement Company. Mr. Carl Weber, President of the Torcrete Shipbuilding Company and Mr. Jens Hauland, General Manager of the Porsgrund Cement Stoeberi of Porsgrund, Norway, also gave valuable assistance in person, while Mr. Oscar F. Lackay and Mr. Lee Heidenreich contributed by letter. Other data were secured

from various sources, principally magazines and these are included in the bibliography at the close of this thesis.

Influence of the first pamphlet prepared by the author will naturally be seen in this thesis, nor has any attempt been made to change some of the wording since this is actually his own. The subject matter has been revised to correspond with more recent information altho the progress in this field is so rapid that it is physically impossible to present an up-to-date historical sketch.

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INTRODUCTION

Ship construction as demanded by war conditions is different in some respects to that of normal times. The elements of speedy construction and standardization, labor conditions and substitution of materials not required in enormous quantities for war work make changes in design and methods essential. Where formerly plate mills were able to supply steel in this shape in sufficient quantities, they are now over-taxed with other demands. Steel itself is required for other uses, hence the desire to utilize materials that are not in as great demand , and also that can utilize labor which would remain idle, or at least would not produce results up to full capacity.

Wood, of course, was the first material that suggested itself, but it was soon found impossible to secure this of the grade and seasoning necessary in the quantities demanded. Concrete, therefore,has suggested itself as a possible solution to the shipping problem and research along this line,as well as actual construction,is progressing rapidly. It is impractical to attempt to demonstrate the fundamental theory underlying concrete ship design. In fact, at the present time it is impossible, for this has not all been developed. The overcoming of shearing forces in a ship's hull, perhaps the greatest difficulty in concrete ship design, awaits further tests on slabs and beams constructed for this purpose.

If concrete ships become economically practical, however, they will possess certain qualities which the illustrations given

in this thesis will prove and thus make ships of this material highly desirable. For instance, the large part of the labor required is of the less skilled type; steel used is principally bar-shaped; speedy construction, not possible heretofore, may be obtained; corrosive action of the elements upon the steel is diminished; animal and vegetable growths that retard propulsion are eliminated to a great extent; maintenance costs are greatly reduced; caulking, painting and similar maintenance is eliminated; fire hazards are lessened; wood boring worms are guarded against; hull's shapes not possible heretofore may be utilized and many other advantages secured.

Ship design and construction has been greatly governed by the rule of thumb. Lloyd's rules, rather than fundamental mechanical principles, have been a guide to the marine architect. In concrete ships, however, there has been no opportunity to develop such haphazard methods and modern science will hardly permit the use of designs developed in this fashion. Just how to provide for the strains in a ship's hull is still a debatable question, and until the Department of Concrete Ships of the United States Shipping Board formulates standard rules, this will probably remain without an official guide. It is to be hoped therefore that the work which has been done at Washington during the winter of 1917-18, will be continued so that the world may have the lasting benefit of this enterprise.

Review of the existing concrete ships will be of interest and the author hopes of value. However, dearth of information, from an engineering point of view, makes it necessary to offer an explanation of the incompleteness of the descriptions. It is to

be hoped that hence-forth concrete ship builders will be more liberal with the information they possess, and assist in the progress of an industry that will only succeed if all concerned help one another.

- - -

CHAPTER I.

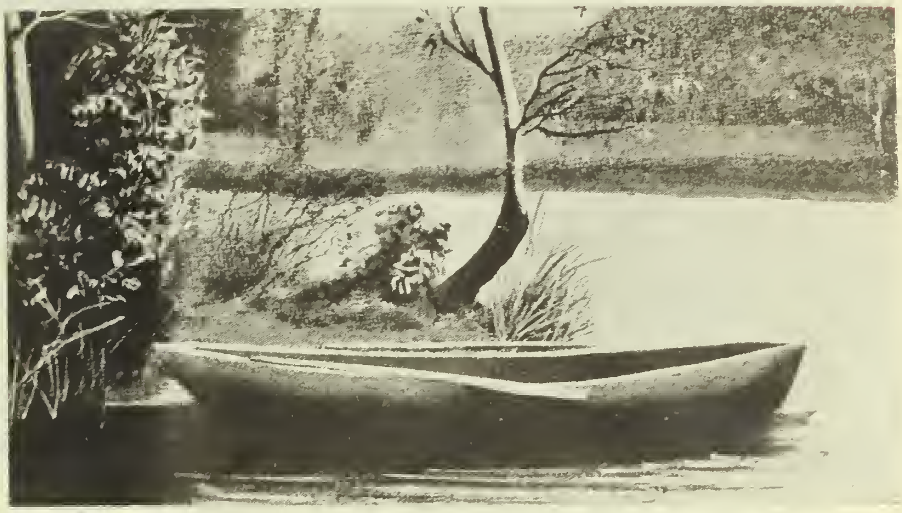
EARLY CONCRETE SHIPS.

Historical reviews of progress in construction work frequently begin by describing the work of the ancient Egyptians. In this respect the study of the progress made in concrete ship construction is not very different from that of other fields of endeavor. The rush-basket in which Moses is supposed to have been found was probably of the type employed by the Egyptians in which a woven reed basket was made watertight by applying a clay stucco. This material did not lend itself to great stresses, however, and we find therefore no great developments in this construction.

Wood, naturally because of the fact that it required no additional buoyancy to float upon water, became for many centuries the accepted material for ship construction and not until steel plates were manufactured of sizes applicable to hull-plating was it found that a lighter and more substantial construction could be effected with this material. To the minds of many at that time the great weight of iron and steel seemed an inseparable bar to the successful construction of metal vessels. The fact that a much stronger ship could be constructed which at the same time was lighter than a wooden one, has caused this type of vessel, however, to practically supersede its competitor and now we find but little discussion as to the relative safety of wood and steel vessels.

FIRST APPLICATION OF REINFORCED CONCRETE

Just why reinforced concrete has not received active consideration heretofore in ship construction is hard to explain. In a boat, reinforced concrete was employed for the first time so far as we have any record. In 1849, M. Lambot of Carces, France, built a row-boat which made use of the first known application of reinforced concrete. This structure, marked the starting point of the history, not only of concrete boat building but of reinforced concrete. The boat was exhibited by its maker and patentee at the World's Fair in Paris in 1854 where it attracted the attention of many visitors. The idea at that time was to substitute reinforced concrete for the timber planks, the concrete planking being made by placing a coat of mortar upon an iron netting or lattice work. This boat after more than fifty years of service was still in use on the Lambot estate prior to the present war.



FIRST REINFORCED CONCRETE STRUCTURE

M. Lambot's early departure in the method of boat building was investigated by the French government in 1850, but as is often the case, further developments were left to private individuals. From this simple beginning reinforced concrete construction has developed to the point where today it enters into the building of practically every known type of structure.

ACHIEVEMENTS OF THE DUTCH

So far as known there was no intervening attempt at building a reinforced concrete boat between M. Lambot's first skiff and the construction of the sloop "DeZeemeuv" in 1887 by Zementeisenfabrik Gebrueder Picha-Stevens of Sas van Gent, Holland. This sloop, which at the present time is in the possession of the Amsterdam factory of Fabrieck van Cement-Ijzer Werken, of Amsterdam, is still in a very good condition * despite the fact that it has had quite a number of collisions and has repeatedly been hauled upon a basalt embankment and frozen fast every winter. In later years it was used for duck hunting where it was found very useful because of its inherent higher stability.

The construction of this sloop was followed by the building of barges 64 feet long and 14 feet beam of 55 ton capacity. The system of construction employed consisted of rectangular and transverse bulkheads spaced approximately on 6 feet centers, thus providing a cellular system which made the vessel practically unsinkable.

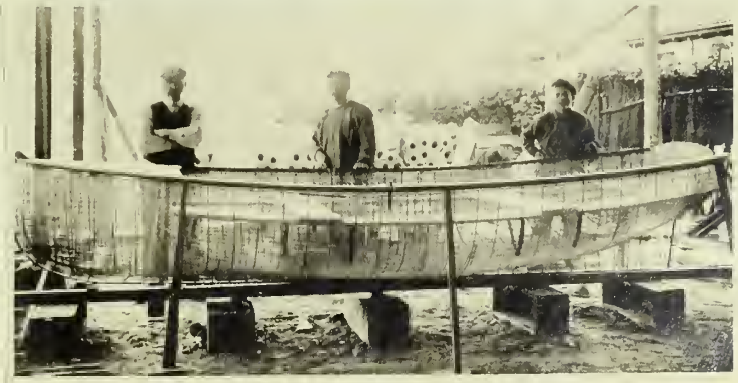
* Beton u. Eisen, March 14,1917

Of interest is the small motor boat built by A. Last & Sons, a Holland firm of Enkhuisen. In this case the framework was made up of an iron keel to which were attached iron rods running in two directions and bent to the required shape. A wire mesh covering provided the means by which the mortar shell of one inch of concrete was held in place. This was plastered on both sides and gave a very serviceable motor boat.

CONCRETE MOTOR BOAT BUILT BY A. LAST & SONS

ITALIAN SUCCESSES WITH REINFORCED CONCRETE

It may be that others attempted the construction of larger concrete vessels in the period of 1887 and 1896, but if this is the case, no records concerning them are available. In 1896, Carlo Gabellini of Rome, Italy, attacked the problem on a larger scale. His first structures were more in the nature of pontoons, several of these being used to carry the quarters of a rowing club at Rome. These possessed a great ability to withstand abuse and therefore lead to the construction of barges that were intended for towing. The method of construction and design had developed to such an extent by 1905



VIEW OF REINFORCING

that an 150-ton barge was built for the city of Civita Vecchia. The following year another barge was built for use by the Italian navy in the military harbor at Spezzia. The latter barge, before acceptance, was put to the severe test of being driven against some piling and afterward being rammed by a steel towboat. The results of these tests were so satisfactory that the construction of similar barges followed.

BOATHOUSE OF REINFORCED CONCRETE

In 1909 a special representative of "Beton und Eisen" visited the works of Gabellini and made a detailed report of the methods by which these barges were constructed. This description goes into greater detail than do most other references available and yet it too fails to give that information which is so vitally necessary at the present time for the design of reinforced concrete hulls, namely the fundamental theory of design employed. The construction methods,

"LIGURIA", A GABELLINI BOAT,COMPLETED

"ETTORE" BUILT BY GABELLINI

PONTOON FOR BRIDGE USE UNDER CONSTRUCTION

COMPLETED BRIDGE PONTOON

however, will prove interesting.

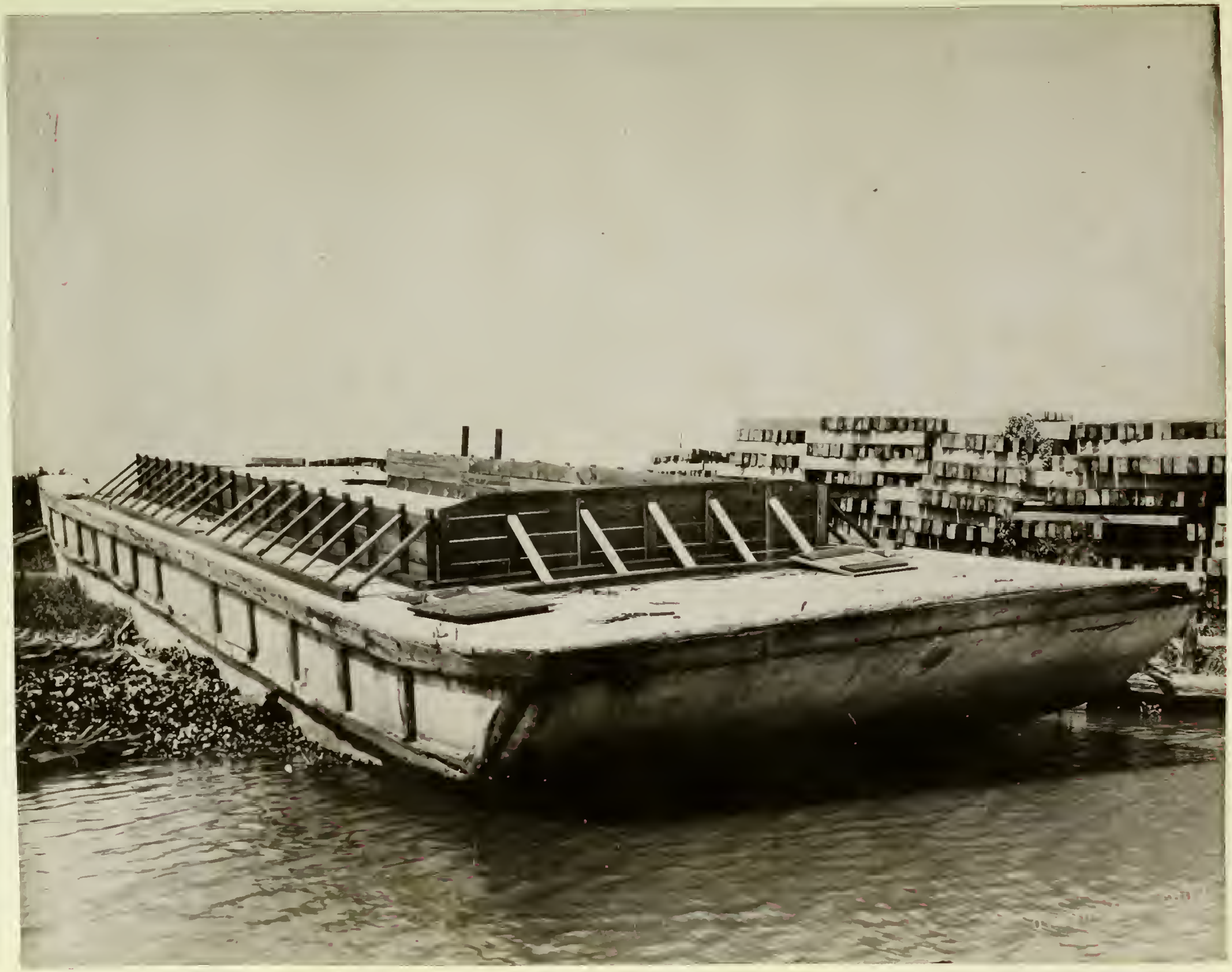
The first step "in laying down" these vessels consists of spacing reinforcement for the keel and ribs. This reinforcement, which was usually round steel rods, is then covered on the outside with 1/4" wire mesh to which a one inch coat of mortar is applied, next a somewhat thinner coat of mortar is placed on the inside, following which, forms for the rib and keel are put in place and concrete placed for these parts of the vessel. These rods run both rectangularly and transverely so that a checker board arrangement results, the pockets being ten inches deep and the

ribs about two inches wide. Over these ribs 1/8 inch wire mesh is placed on which a thin mortar covering is plastered. Finally a third wire mesh is pressed into the soft mortar and the entire surface trowelled over. Bulkheads are next concreted and the boat finished with a wooden strake and gunwale.

At the time the inspection of the Gabellini yards was made there were in process of construction several railroad car ferry floats large enough to carry six coaches. These floats were intended for use at the railroad ferry in Venice. They were designed to take rails 154 ft. long.

Italy also has other examples of floating concrete structures that have been built in the last 2 decade. In 1900 a bridge across the Po River was constructed using a number of reinforced concrete pontoons. These we are informed have not cost one cent for ~~their~~ maintenance up to the present and are still in the best condition. In view of the fact that wooden pontoons on this river required complete overhauling after five years, while after nine or ten they are utterly useless, the value of reinforced concrete for this purpose is clearly demonstrated , since their period of usefulness covers seventeen years without incurring any maintenance expenses.

Pontoon bridges are quite popular in Italy. The economy demonstrated by those over the Po has resulted in replacing the wooden pontoons in the provinces Pavia, Reggio, Emilia and Mantuna with those of reinforced concrete, so that now there are hundreds of these in service.



CONCRETE BARGE AT MOBILE, BUILT ACCORDING TO CABELLINI DESIGNS

CHAPTER II

TWENTIETH CENTURY CONCRETE SHIPS

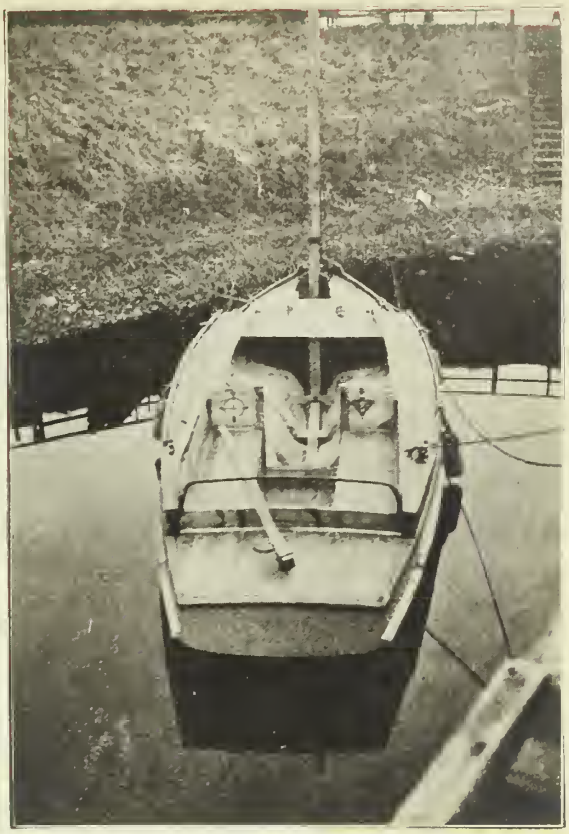
It is noticeable that all vessels described so far have either been of the small pleasure boat variety or of the barge type. In no instance was any attempt made to construct ocean going vessels capable of carrying large cargoes. This is not alone true of France and Italy but also of the other nations in which vessels of reinforced concrete were constructed prior to 1917.

GERMAN EXPERIENCES

Perhaps the nearest approach to vessels having full ship lines was made by the Germans in 1909. Following the precedent established by the Dutch, the Allgemeine Verbund-Bau Gesellschaft constructed a concrete freighter of 220-ton capacity. In this vessel complete forms were set up and the concrete placed between them. The result was a boat, the hull of which had parallel sides, yet possessed a shape with fairly good lines so that water-resistance was decreased below that of a rectangular barge. Rectangular compartments forming watertight bulkheads, similar to those used by the Dutch, were a factor of construction. A small after cabin completed the vessel.

In 1912 Herr Johannis Lescher of Dresden conceived the idea of building a concrete sailboat. His design embodied the latest principles of sailing vessel construction with reference to shape of hull and method of computing stresses. Designs were worked out for three conditions - floating in

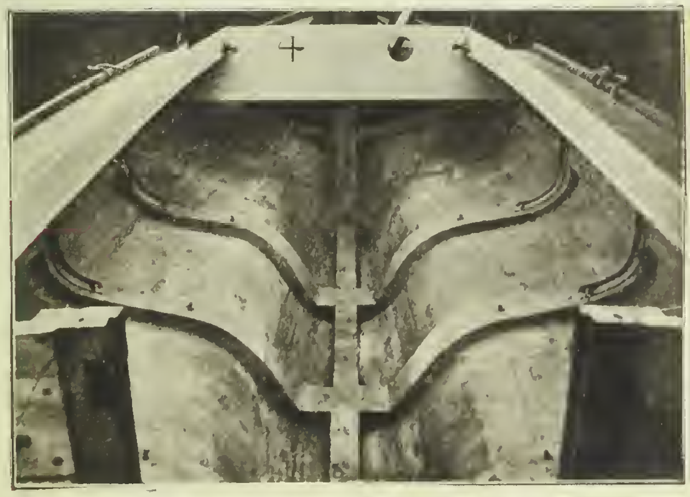
disturbed water; to withstand lifting with a single crane and to rest on its keel on dry land filled with water. This boat was launched in April 1912 and in spite of frequent groundings gave excellent service for nine months following its completion since which time no further record is available.



THE "LESCHER" SAILBOAT

BARGES ON THE PANAMA CANAL

Concrete barges built on the Panama Canal in 1911 are good examples of what service such vessels can render under adverse conditions. In this case concrete was selected as a construction material because no skilled labor for steel or wood construction was available, nor could steel plates or suitable seasoned timber be obtained within the time required. Concrete materials were on hand in sufficient quantity and the expediency of using concrete suggested itself as a solution to the problem.



INTERIOR VIEW SHOWING RIBS.

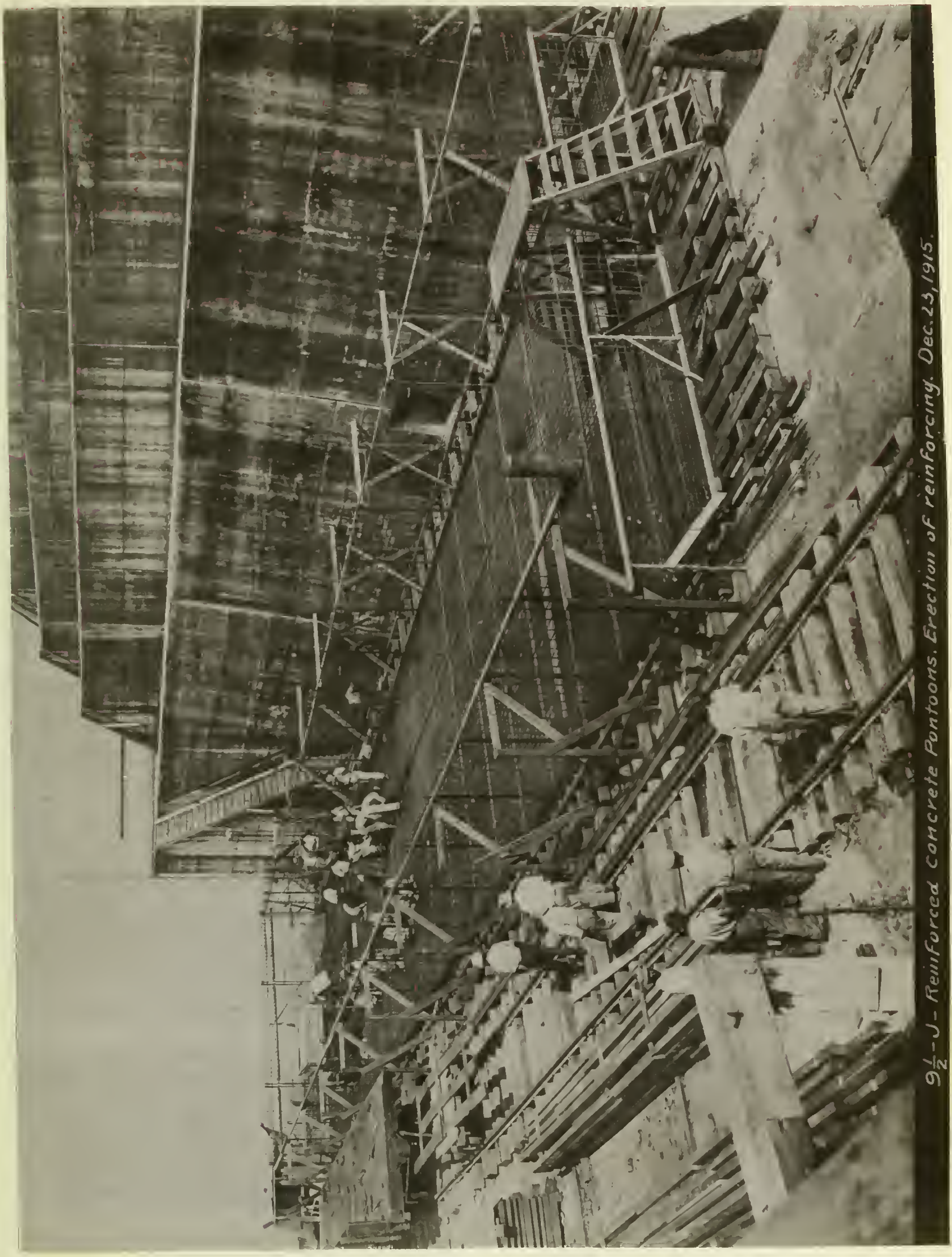
Design of these barges called for a structure 64 ft. long, 24 ft. wide and with a depth ranging from 5 ft. 4in. to 5 ft. 8 in. Walls were made 2½-in. thick. The bracing of the hull consisted of two to three inch bulkheads extending from bow to stern. Reinforcing consisted of 1/2-inch square bars covered by 1/2-inch No.12 wire mesh. Reinforcing was hung in place from wooden beams and properly located by constructing a wooden platform placed at an elevation corresponding to the bottom of the barge. Bars were placed on 9-inch centers lengthwise and 1-ft.2-inch centers crosswise, after which the platform was removed and a net work of reinforcing covered with wire mesh. A 1/2-inch coat of cement mortar was then applied to the mesh. Ten feet of the barge for its entire width were built up at one time. After the hull had been constructed, the bulkheads were poured and a wooden deck put in place. This completed the vessels after which they were launched and put into service.

It must be remembered when considering these barges that they were not intended for severe usage. When, however, they were put into service, it was soon found that to operate them most efficiently, it was necessary to ground the barges and have as little water as possible in the place that was being dredged. This naturally resulted in the barges resting at times upon very uneven ground and in several instances upon boulders and stumps. It is remarkable, therefore, that the barges withstood the service for nearly a year, since each time their bottom was damaged in this fashion, a patch was applied and construction work proceeded. In the opinion of several

engineers in charge of this particular portion of the canal work, neither wood nor steel could have resisted the severe usage to which these barges were put.

Success with these barges led to the selection of concrete as the construction material for other barges and pontoons for use as landing floats. Some of the latter are 120 ft. long, 28-feet wide and 8-feet deep. Work on two of these was started in July and August 1913 and was completed in April and May of the following year. In 1914, four of the same kind were finished. The Panama Canal Record of October 25, 1916, refers as follows to some severe treatment which two of these barges withstood successfully:-

"At the time of the blowing up of the cofferdam behind which the pontoons were built the surface of the water in the entrance basin was about 15 ft. below the mean tide level. The gap made by the explosion did not allow the water to pour in from the sea until the tide rose. The stream which broke over the dam at high tide cut an increasing current sufficient to make the barges part their moorings and circle about the basin. In so doing one of them struck a fender pile and broke it at a point about 20-feet below the butt, where its diameter was about 12-inches. The barge groaned under the impact, and one of the end timbers was sheared off, dragging its anchor bolts through the concrete and causing it to crack. This damage was above the water line. In other respects the pontoon was uninjured. The two pontoons collided once in their course around the basin, but this did no damage to either"



9½-J- Reinforced Concrete Pontoons. Erection of reinforcing. Dec. 23, 1915.

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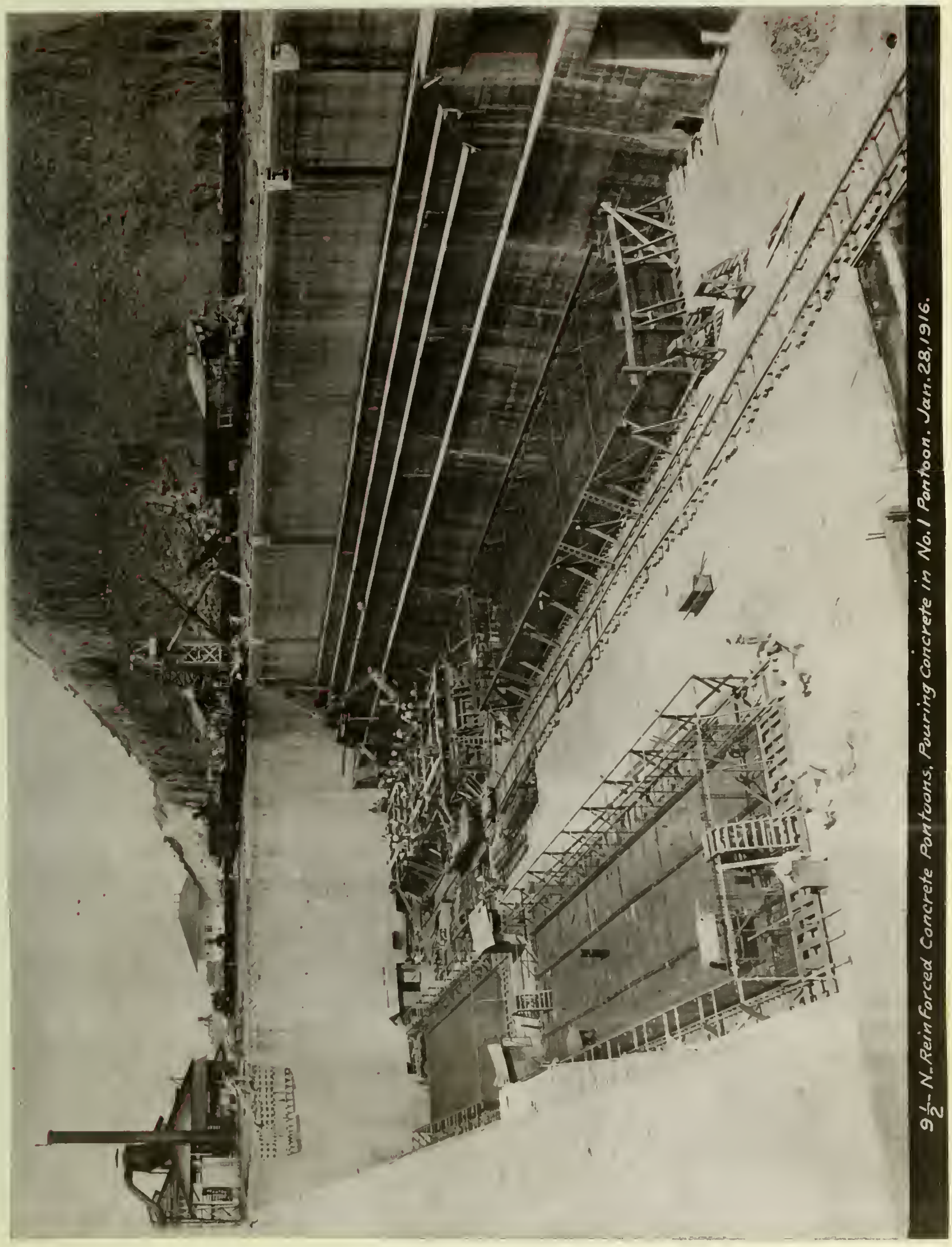
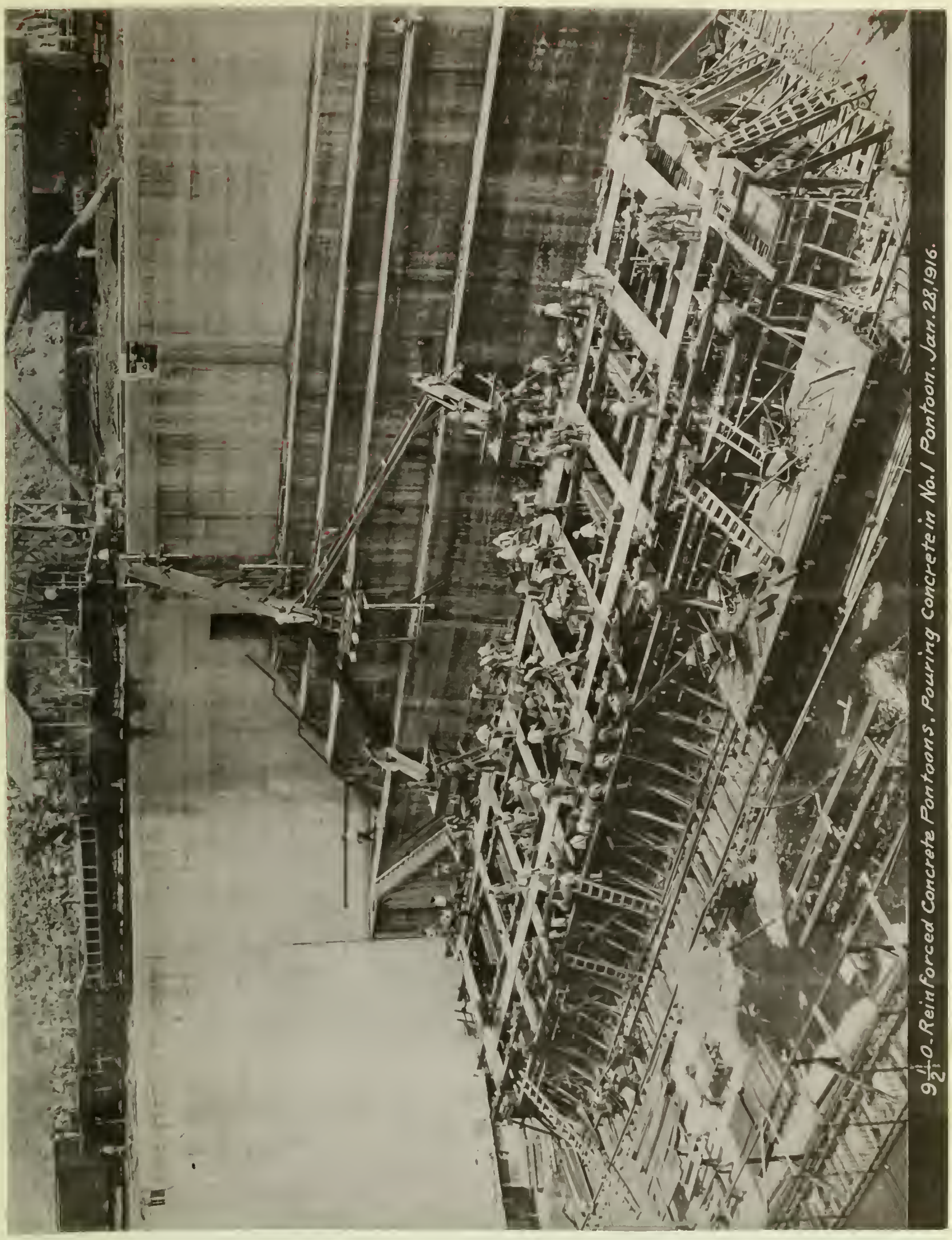
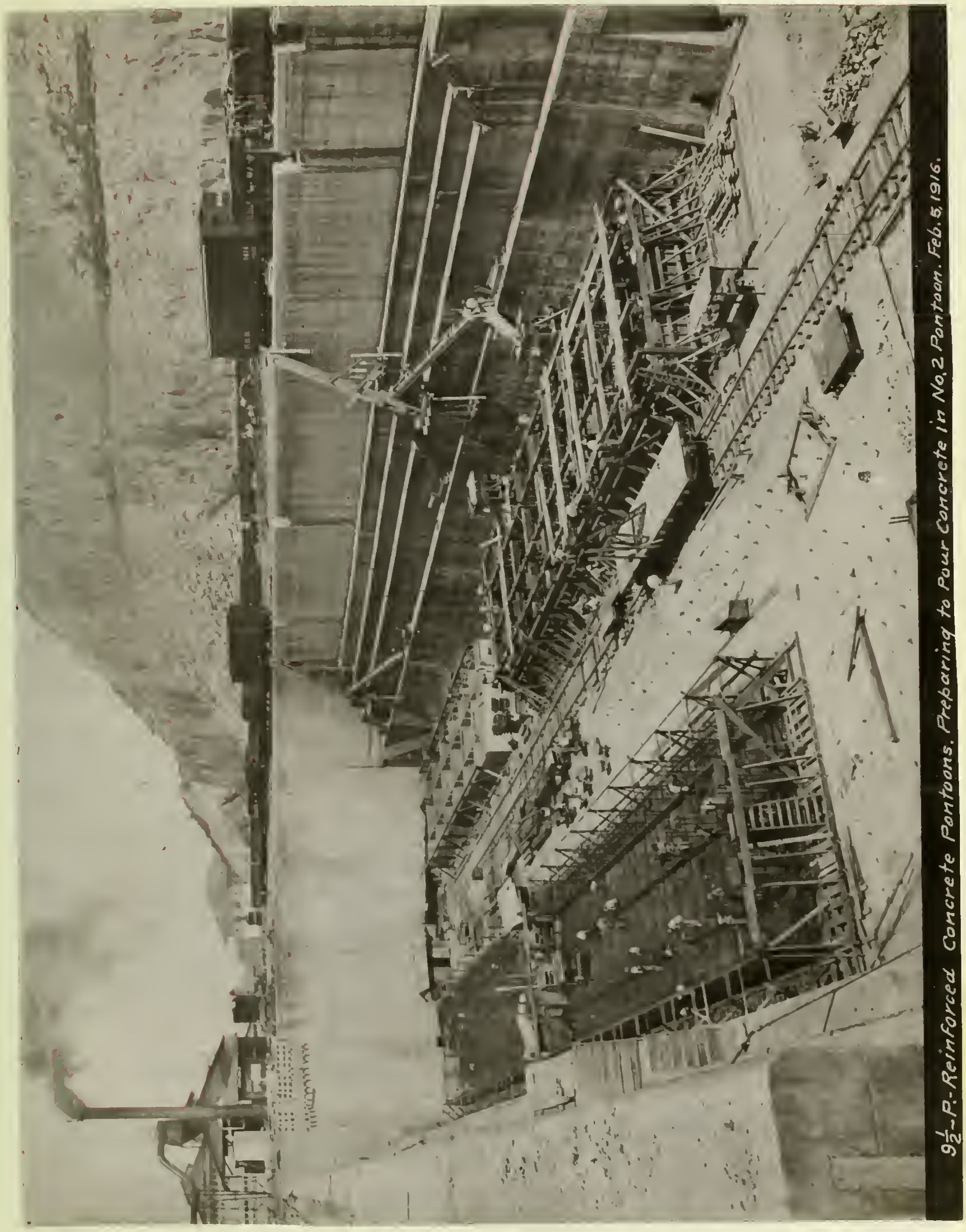


9½ - N. Rein Forced Concrete Pontoons, Pouring Concrete in No.1 Pontoon. Jan. 28, 1916.



9½0. Reinforced Concrete Pontoons, Pouring Concrete in No. 1 Pontoon. Jan. 28, 1916.



9½-P.-Reinforced Concrete Pontoons. Preparing to Pour Concrete in No.2 Pontoon. Feb.5,1916.

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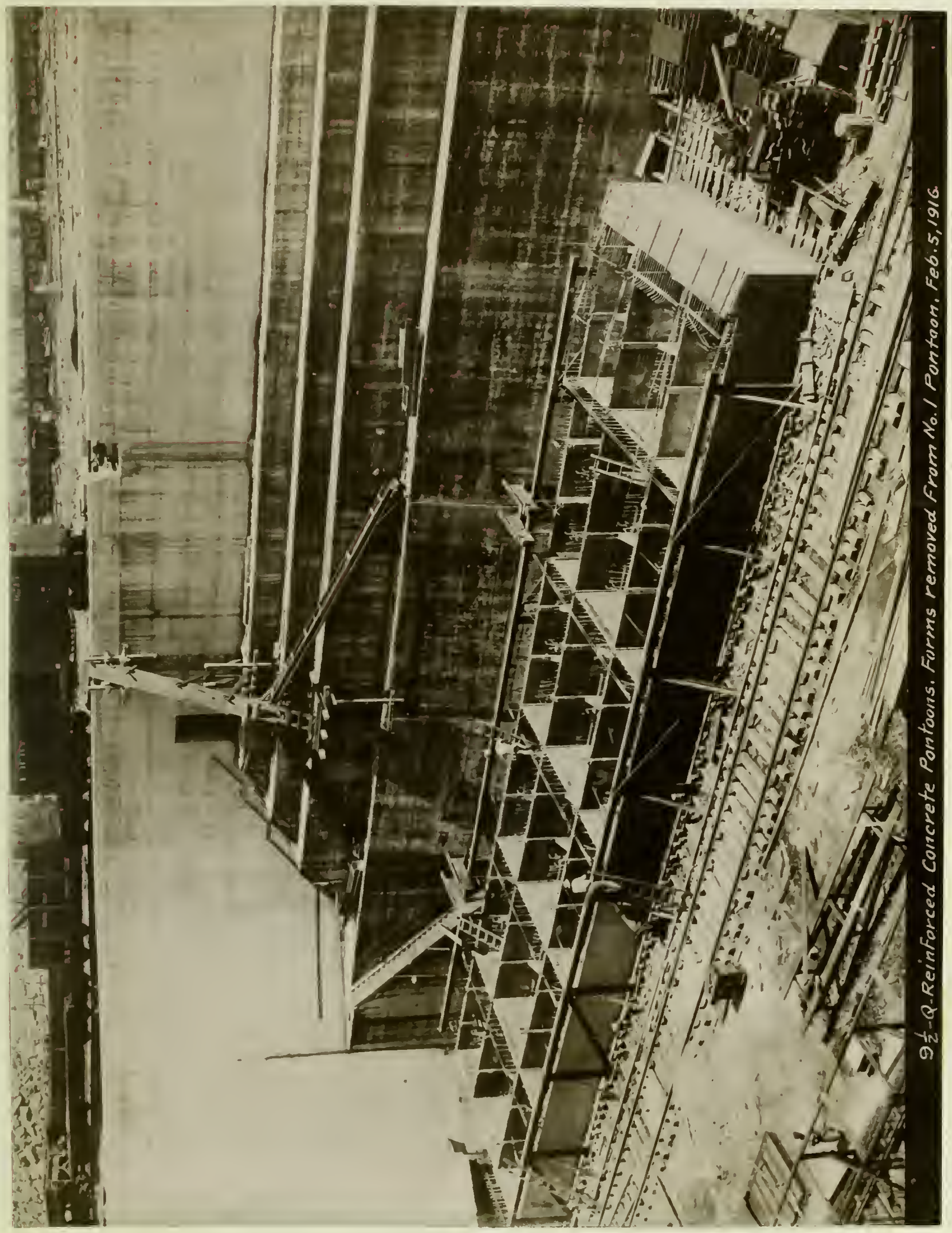
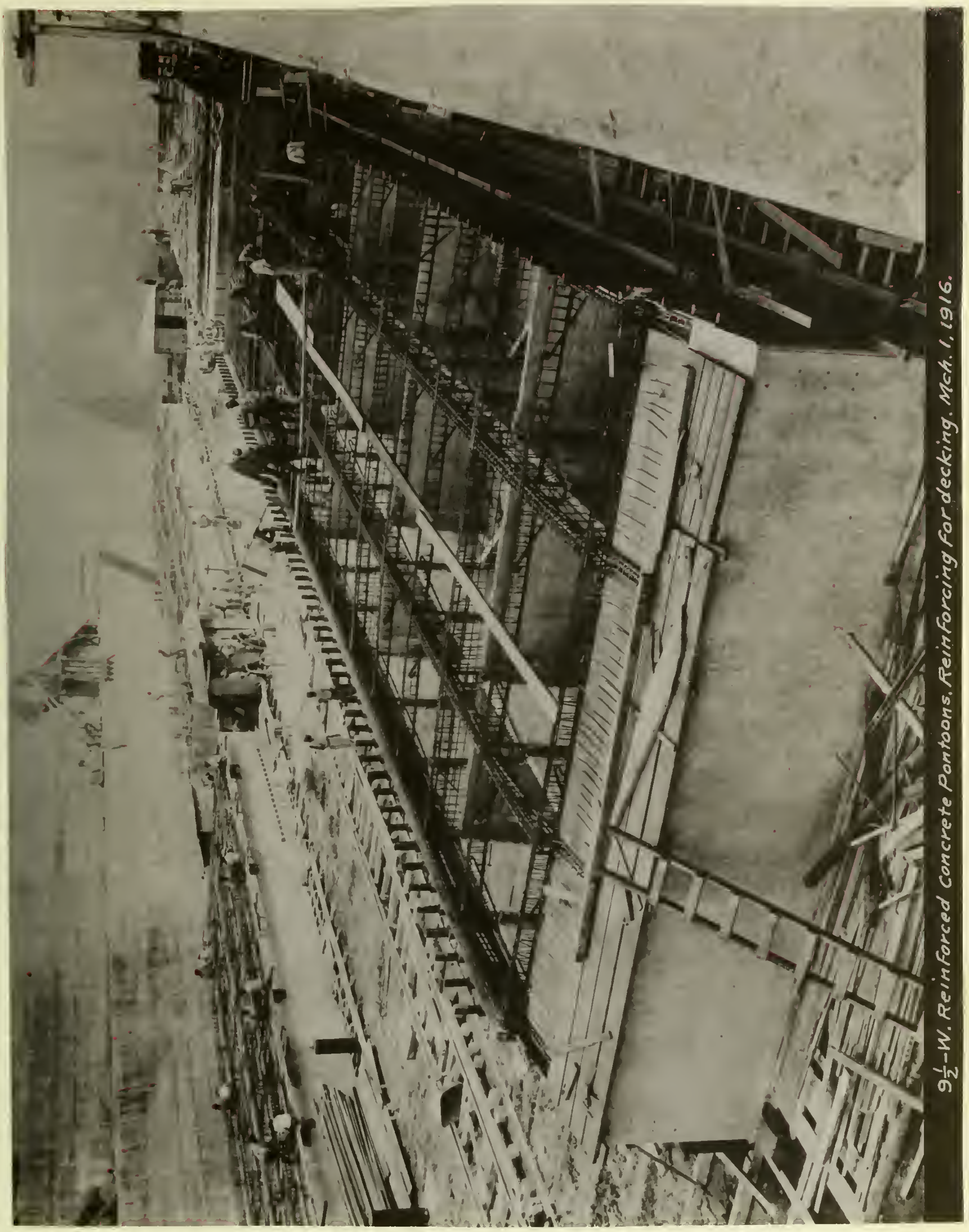
PROGRESS PHOTOGRAPHS OF PANAMA PONTOONS



9½-Q. Reinforced Concrete Pontoons. Forms removed From No. 1 Pontoon. Feb. 5, 1916.

PROGRESS PHOTOGRAPHS OF PANAMA PONTOONS



9$\frac{1}{2}$-W. Reinforced Concrete Pontoons, Reinforcing for decking. Mch. 1, 1916.

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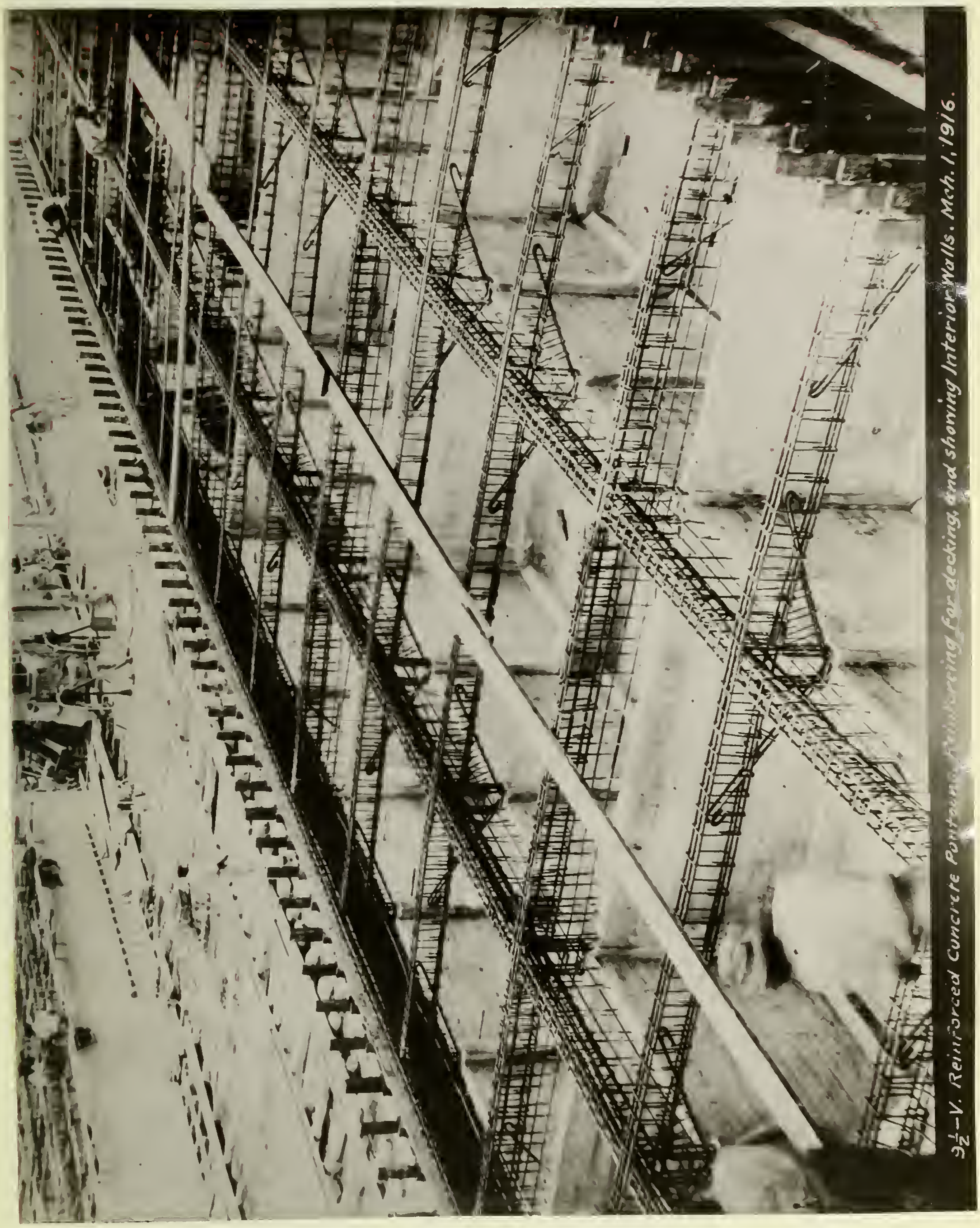
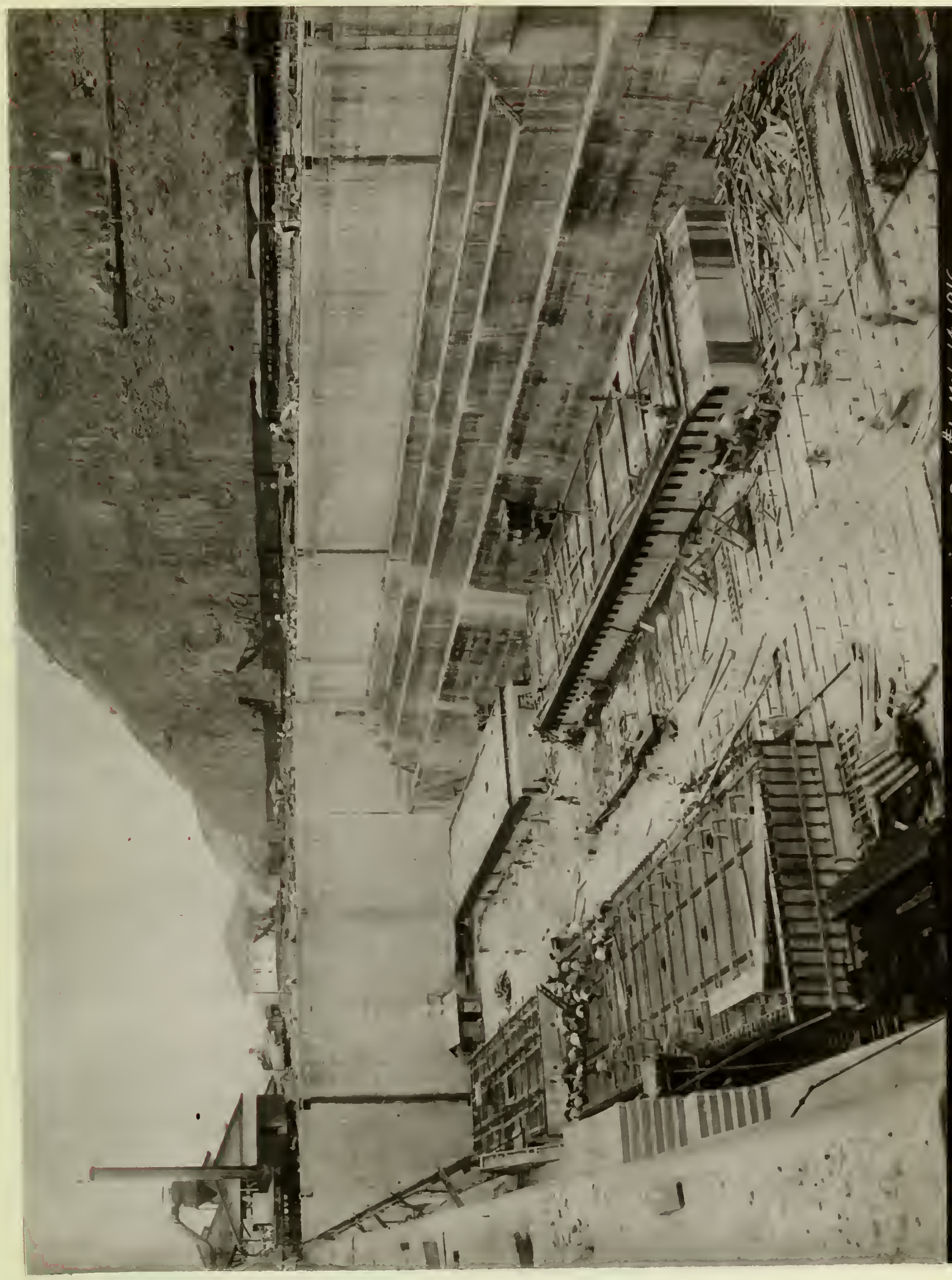


9½-V. Reinforced Concrete Pontoons, Reinforcing for decking, and showing Interior Walls. Mch. 1, 1916.



9½-Y. Reinforced Concrete Pontoons under Construction in Dry Dock #1. Mch. 14, 1916.

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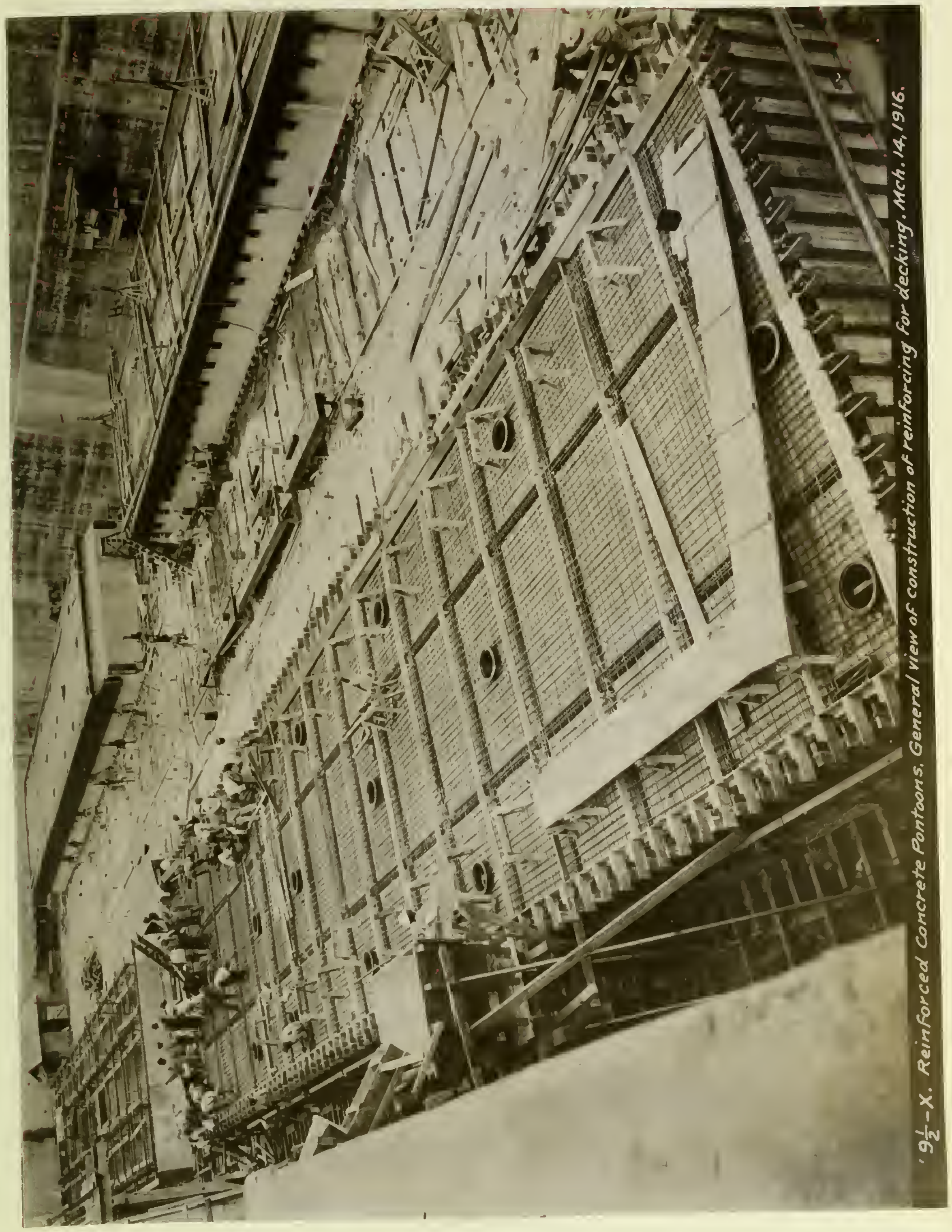
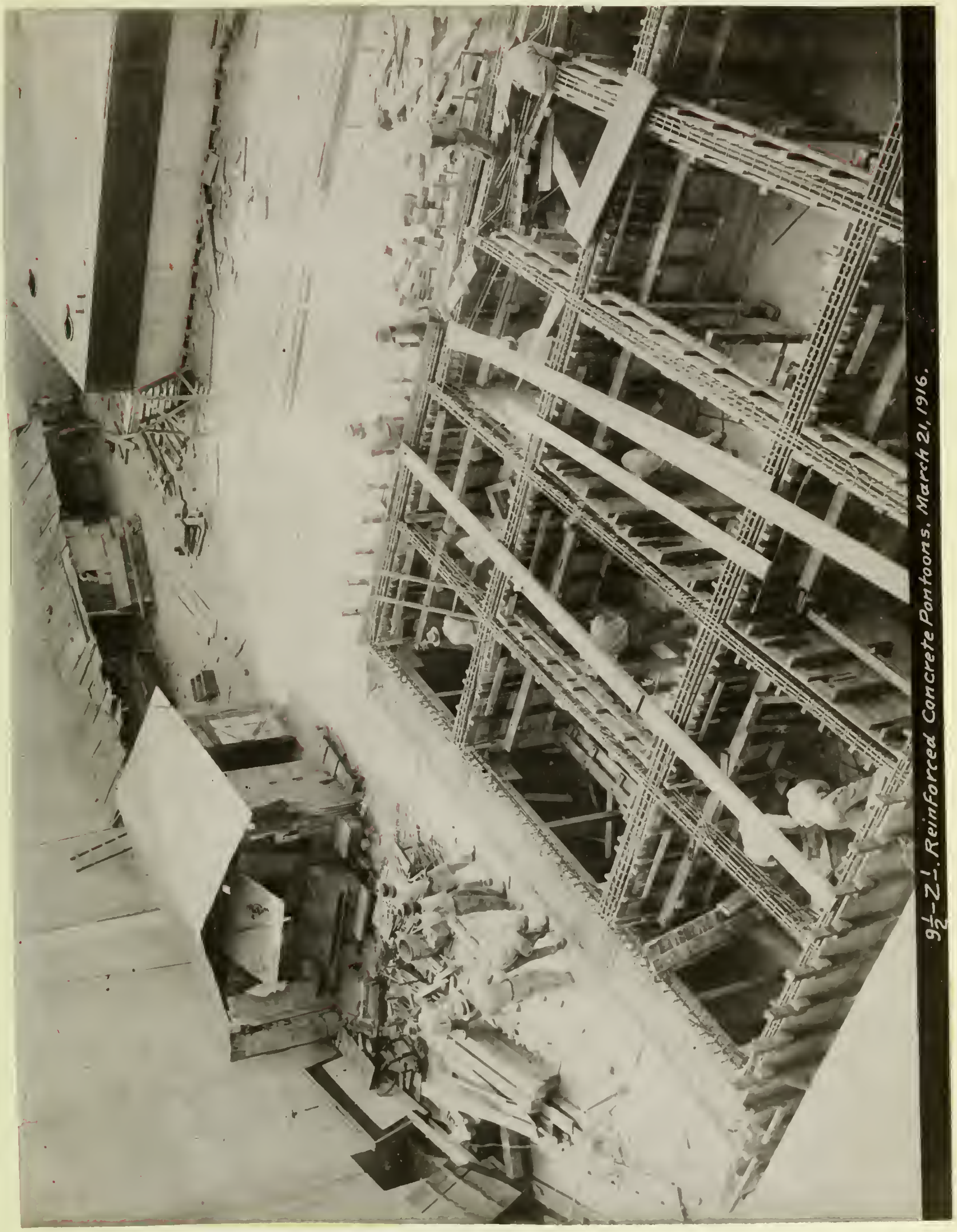
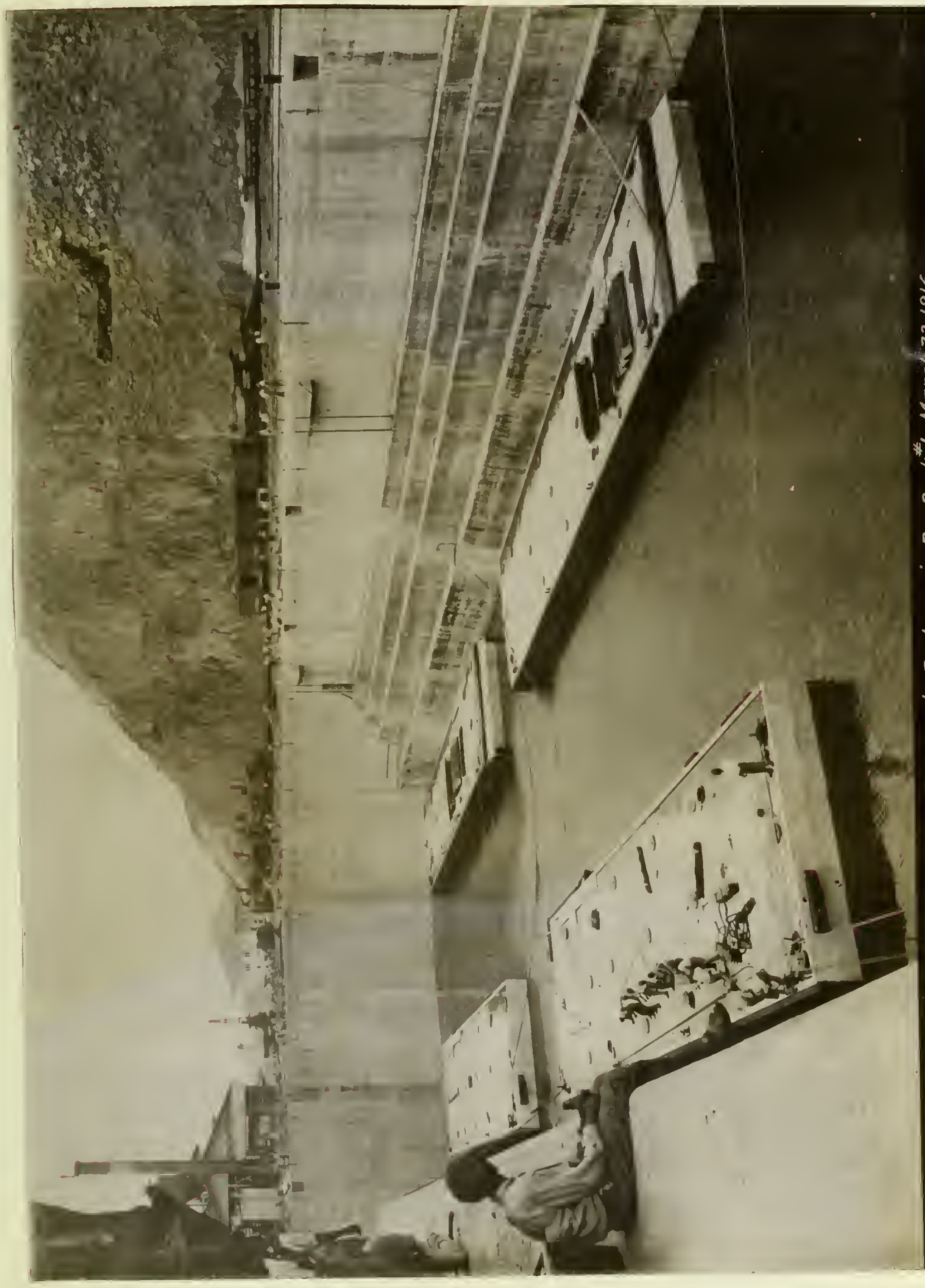


9½-X. Reinforced Concrete Pontoons. General view of construction of reinforcing for decking. Mch. 14, 1916.



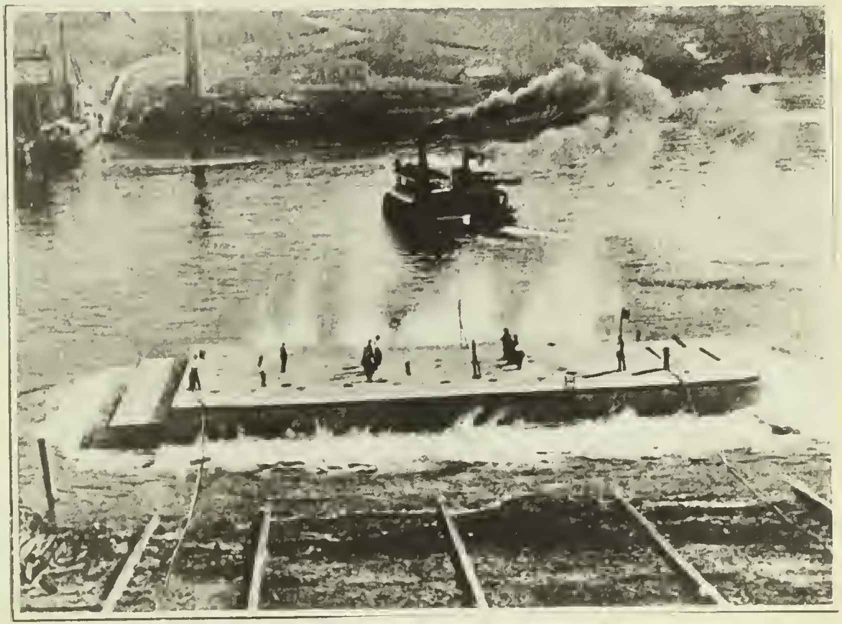
9½-Z1. Reinforced Concrete Pontoons. March 21, 1916.



$9\frac{1}{2}$-2^{2}. Balboa Terminals. Reinforced concrete Pontoons in Dry Dock #1. March 22, 1916.

ENGLISH CONCRETE BARGE

A similar use for reinforced concrete was found on the Manchester Ship Canal, England, where the Yorkshire Hennebique Contracting Company, Ltd., of Leeds, England constructed a 100x125 foot concrete barge. Bottom and walls of this barge are three inches thick except under the boiler room and coal bunkers where they are four inches thick. This was built to carry sludge pumps, boilers and fuel at a very low cost and its maintenance when compared with similar barges, constructed of other materials, has also been found to be much less. Experience has proven in this instance that no interruption in its service is necessary, since needed repairs can be made without dry-docking.



LAUNCHING THE SYDNEY PONTOON

PONTOON OF SYDNEY HARBOR TRUST

In 1914, the Sydney Harbor Trust decided to build a pontoon for use in Circular Quay, Sydney, N.S.W. After investigating various available methods of construction, decision was reached to use reinforced concrete, as it seemed likely this material would eventually prove cheapest because of durability and low maintenance. This pontoon

is 100-feet long, 53-feet,3-inches wide at the bow, 67-feet 7-inches at the stern, has a draft of 7-feet and deck area of 6,000 square feet. The total displacement is 783-tons. 342 cubic yards of concrete and 43-tons of reinforcing steel were used in its construction. The bottom of this barge is 5-inches thick. Bulkheads, four inches thick, divide the whole into 44 compartments which support an 8-inch concrete floor, or deck.

WELLAND CANAL BARGE

That concrete barges can successfully withstand rough usage is well illustrated by experience with a concrete barge in use on the Welland Canal, Canada. This was launched November 9,1910, since which time it has been used principally to carry stone. The barge measures 80x24 feet and has a draft of 7-feet. At times whole carloads of stone from dump cars were dropped upon its deck from a 12 ft. trestle without injury. An article in Engineering News, of January 4, 1915, called attention to the satisfactory service which this boat had given for four years. This period was sufficient to reveal defects, had there been any. The fact, that no serious ones were disclosed helps prove that concrete barges are a success.

BALTIMORE BARGES

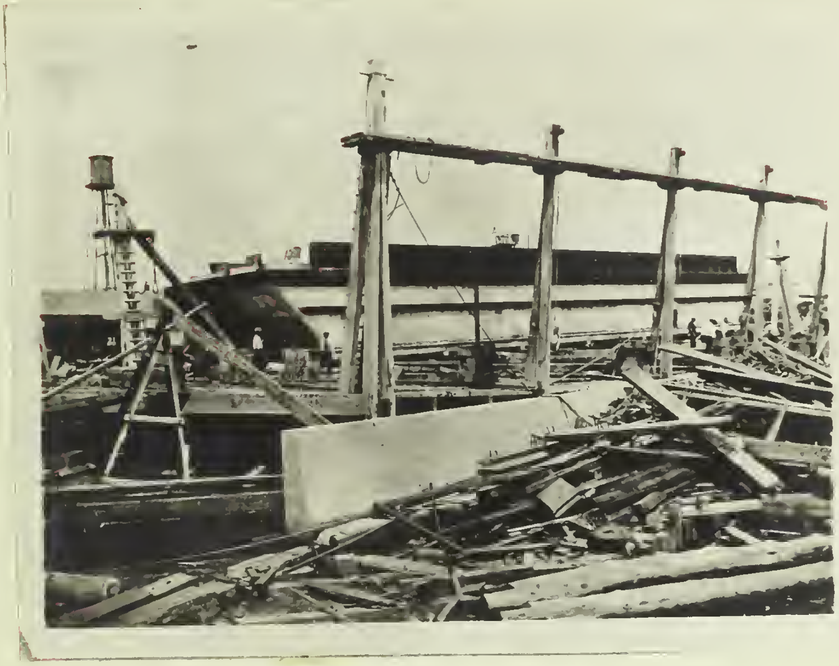
It would seem from the description already given that the United States had fallen far behind other countries in the construction of reinforced concrete vessels. While no claims of priority can be made for construction work of this kind in the United States, some excellent examples have been pro-

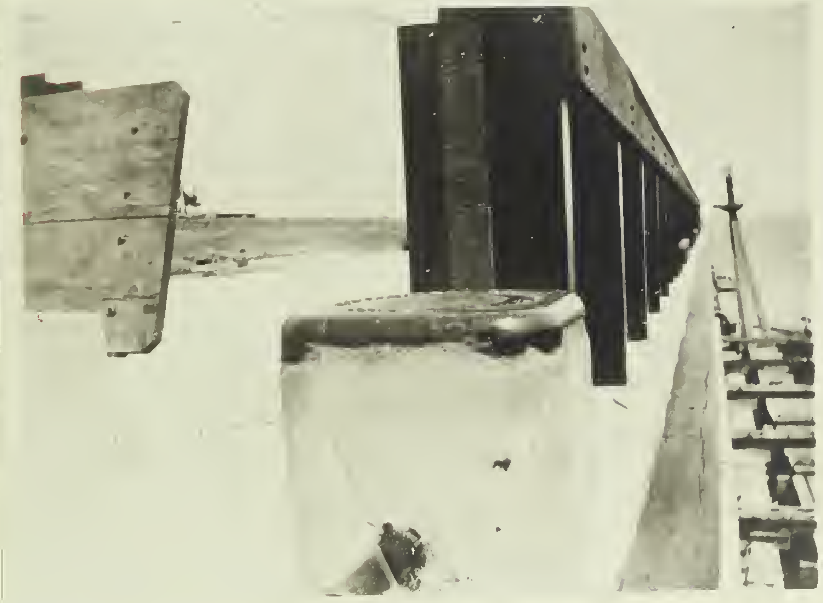
DUMPING STONE ON FOUR-YEAR OLD
WELLAND CANAL BARGE

duced on our shores.

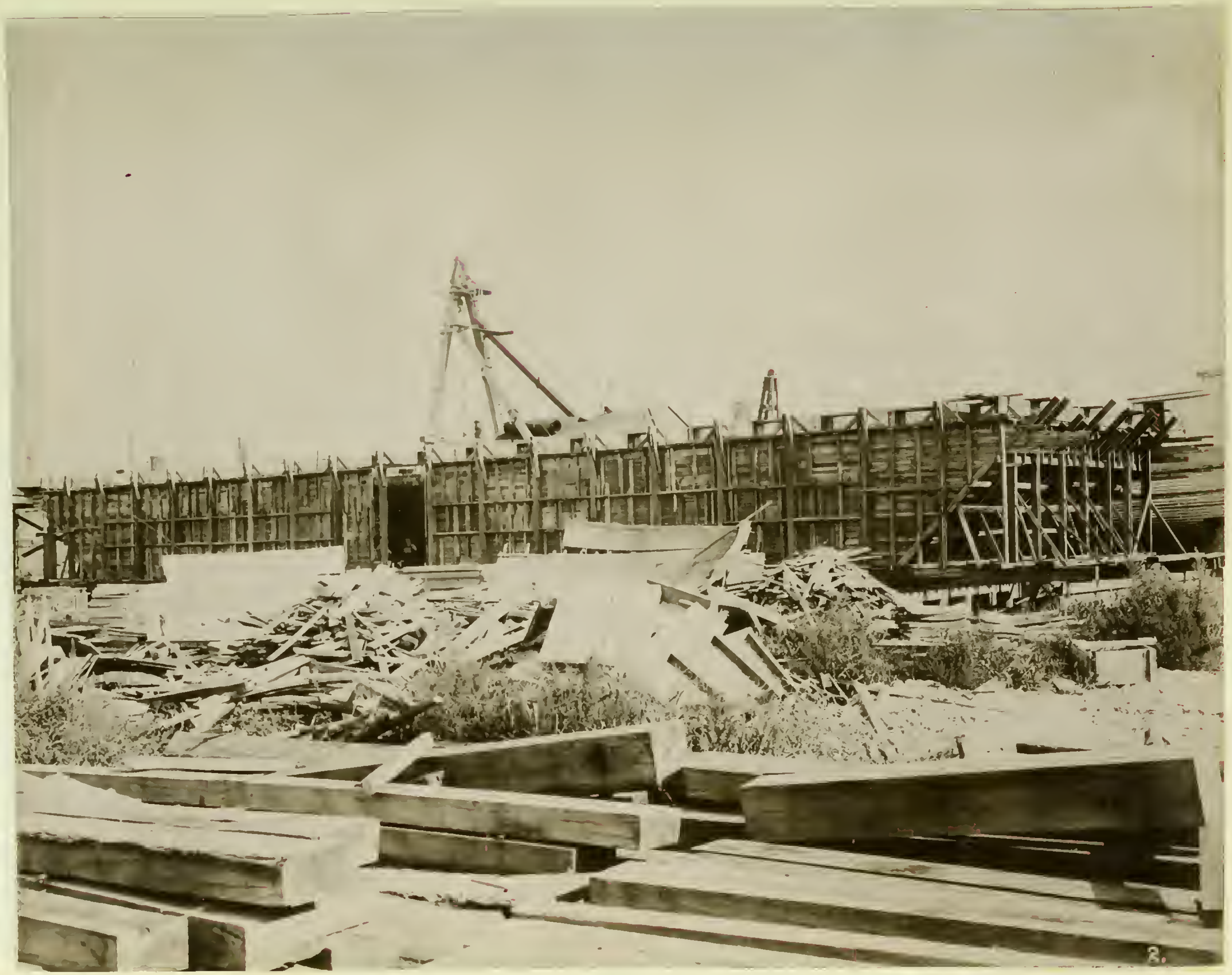
Oscar F. Lackey, while harbor engineer of Baltimore, Maryland, developed and patented a system of concrete barge construction. In 1911, his system was applied to building a concrete scow for the Arundel Sand and Gravel Company of Baltimore. This holds 51¼-tons of fresh water and in addition can be used for transporting such materials as sand and stone. Originally designed to carry 86-tons, it has at times been overloaded with 92-tons without damage. It is 50-feet long, 22-feet wide and has a depth of 7-feet. Its bottom, walls and deck are three inches thick. When this scow was finished, a test was made to determine its strength. This consisted of dropping a 6-ton load into the hull. No damage resulted and the scow was immediately put into service. As a result of this experimental construction for the Arundel Sand and Gravel Company, a 500-ton concrete scow was built in 1912, after the same method by the Furst Concrete Scow Construction Company of Baltimore, and completed in four months. The hull was built between forms and a very rich concrete mixture used, the work being done section by section.

SOME VIEWS OF THE"FURST"CONCRETE SCOWS

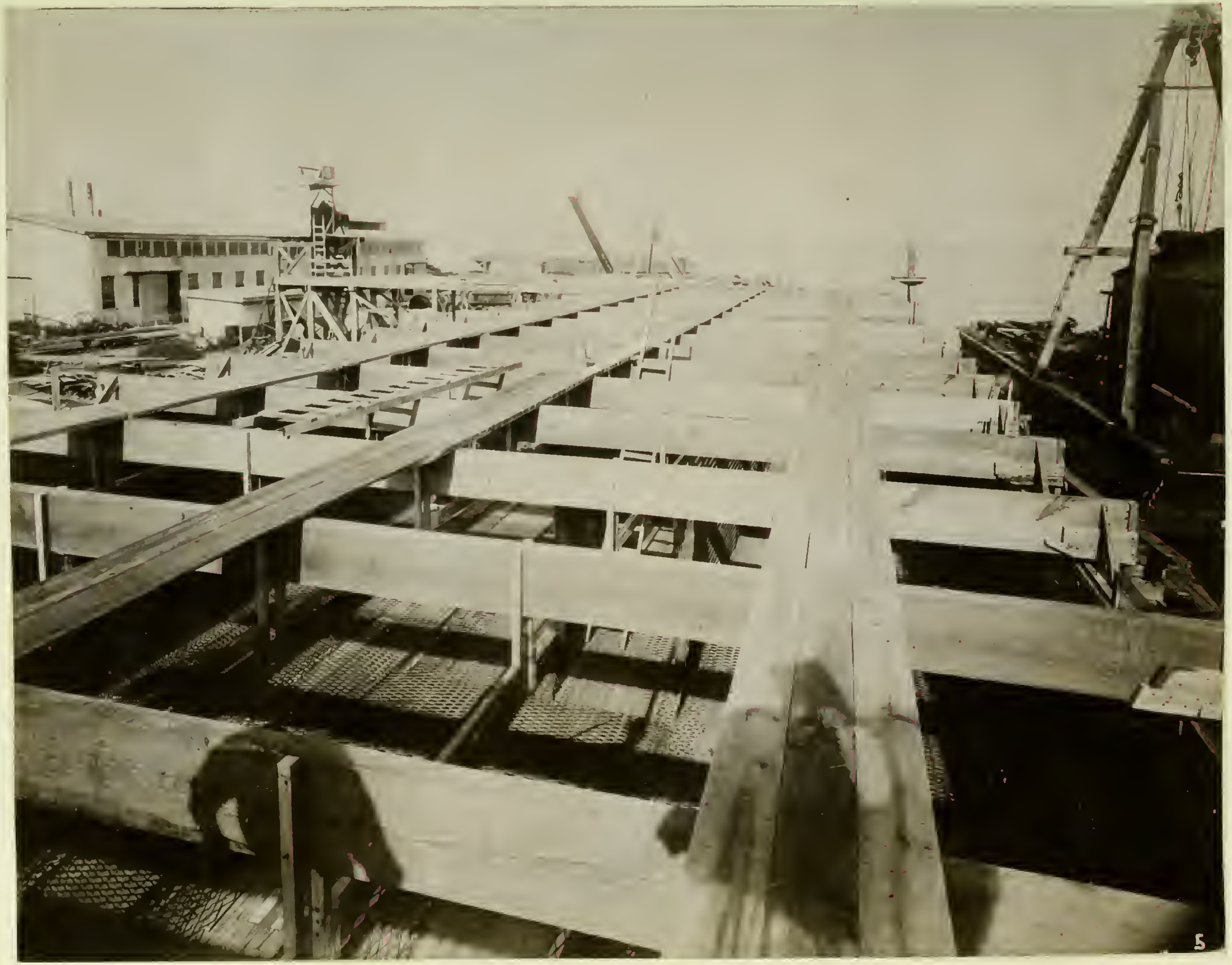




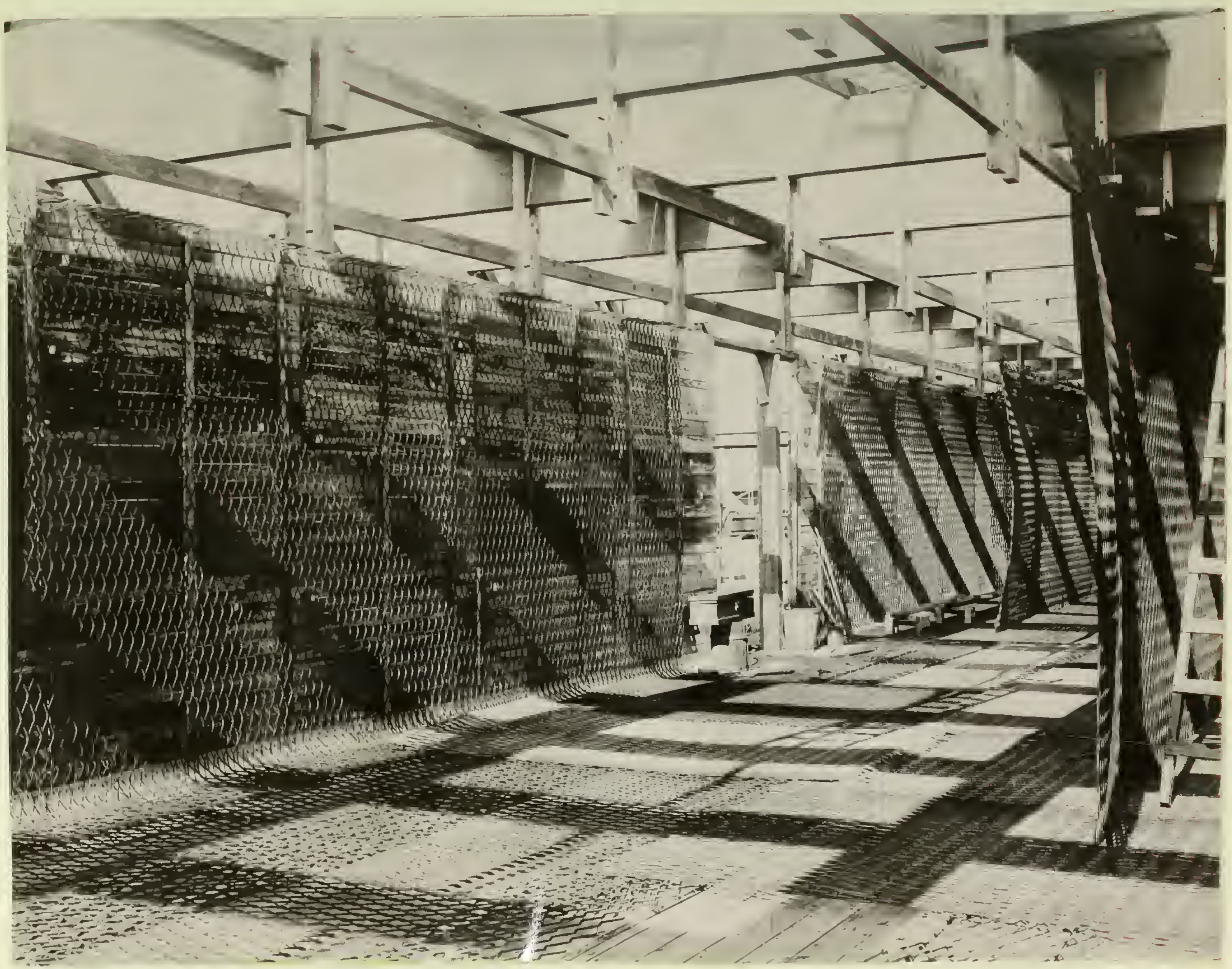
SOME VIEWS OF THE"FURST"CONCRETE SCOWS



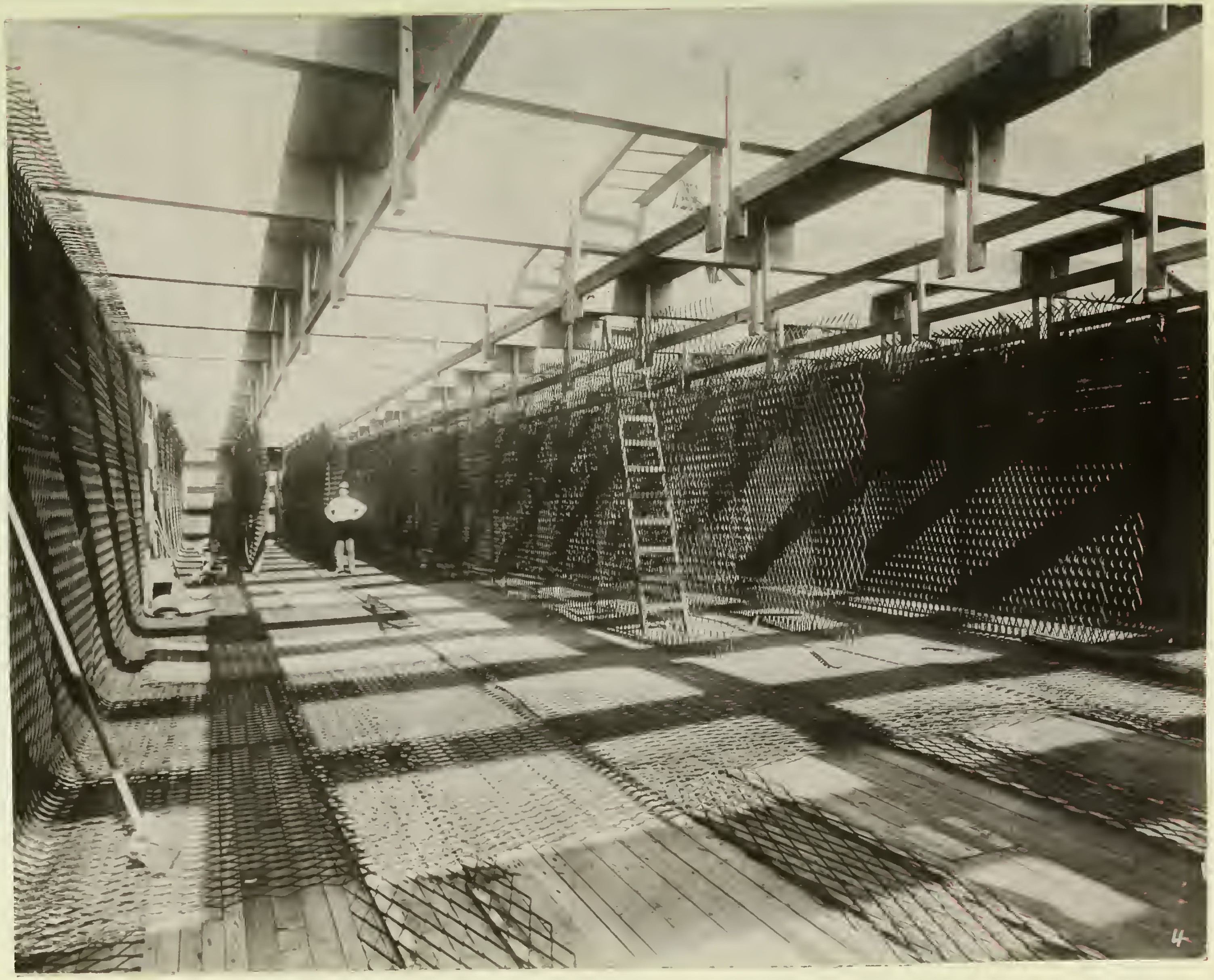
ONE OF THE "FURST" SCOWS UNDER CONSTRUCTION



RUNWAYS ON DECK OF "FURST" SCOW



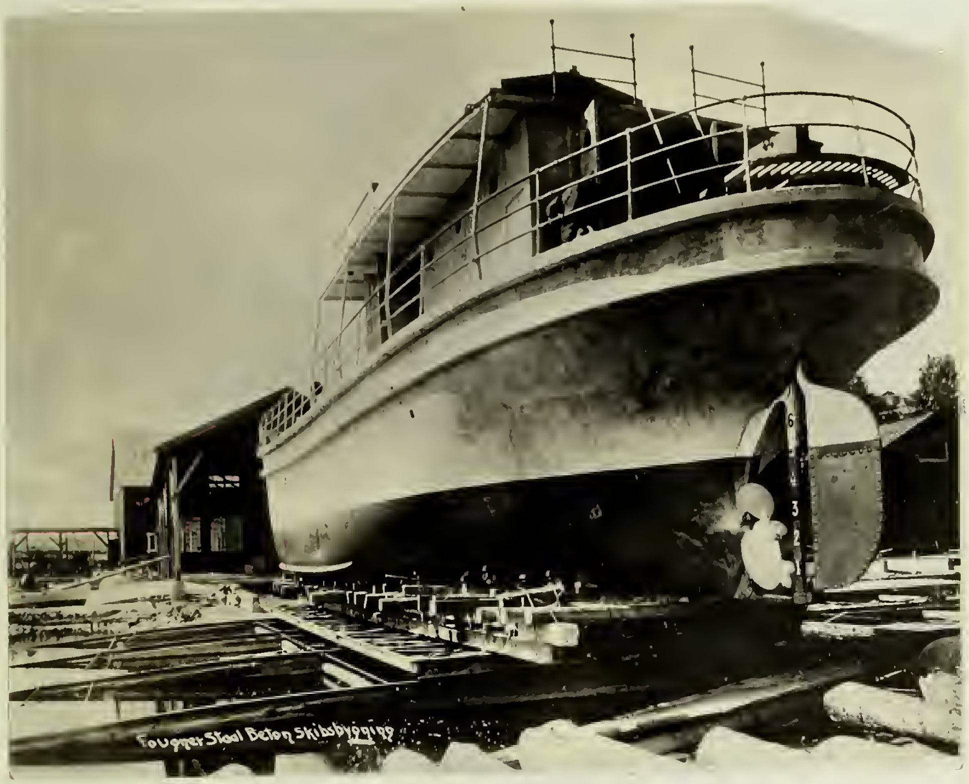
REINFORCING OF "FURST" SCOW



INTERIOR VIEW OF "FURST" SCOW SHOWING PLACING OF REINFORCING

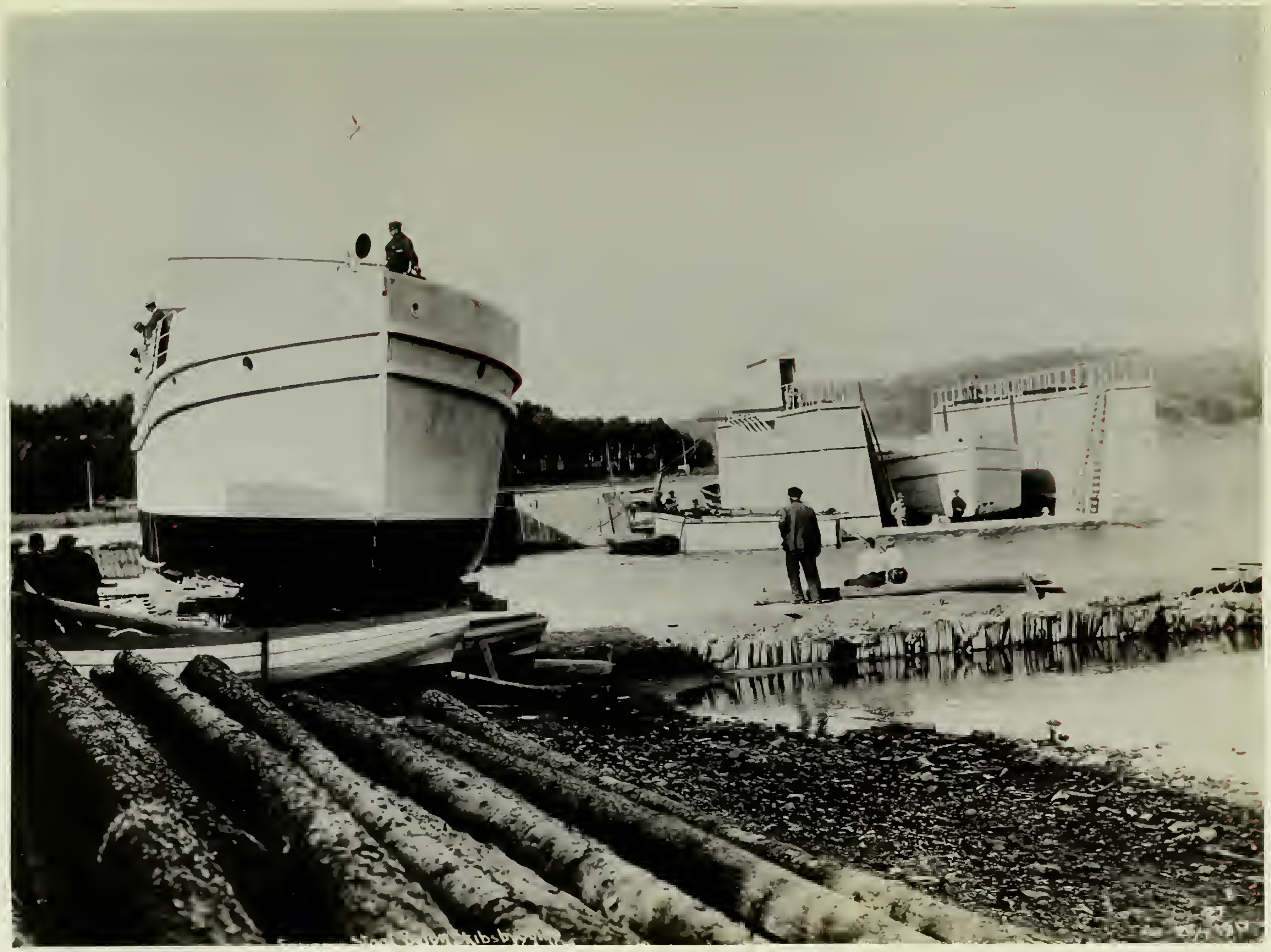
DEVELOPMENTS OF SHIP WORK IN NORWAY

The greatest progress in actual ship construction should be credited to the Norwegians, excepting only the work going on at San Francisco and Montreal, of which account will be made later. A recent advertisement in the Norwegian Shipping Gazette, translated reads:- "Fougner Reinforced Concrete Shipbuilding Co. Lighters of reinforced concrete 100-tons dead weight can be delivered in from six to eight weeks. Seaworthy motor ships about 200-tons dead weight can be delivered in from three to four months. Larger lighters and motor ships up to 3,000 to 4,000 tons dead weight for delivery the first half of next year. Building of floating dry docks can be contracted for the latter half of 1917".

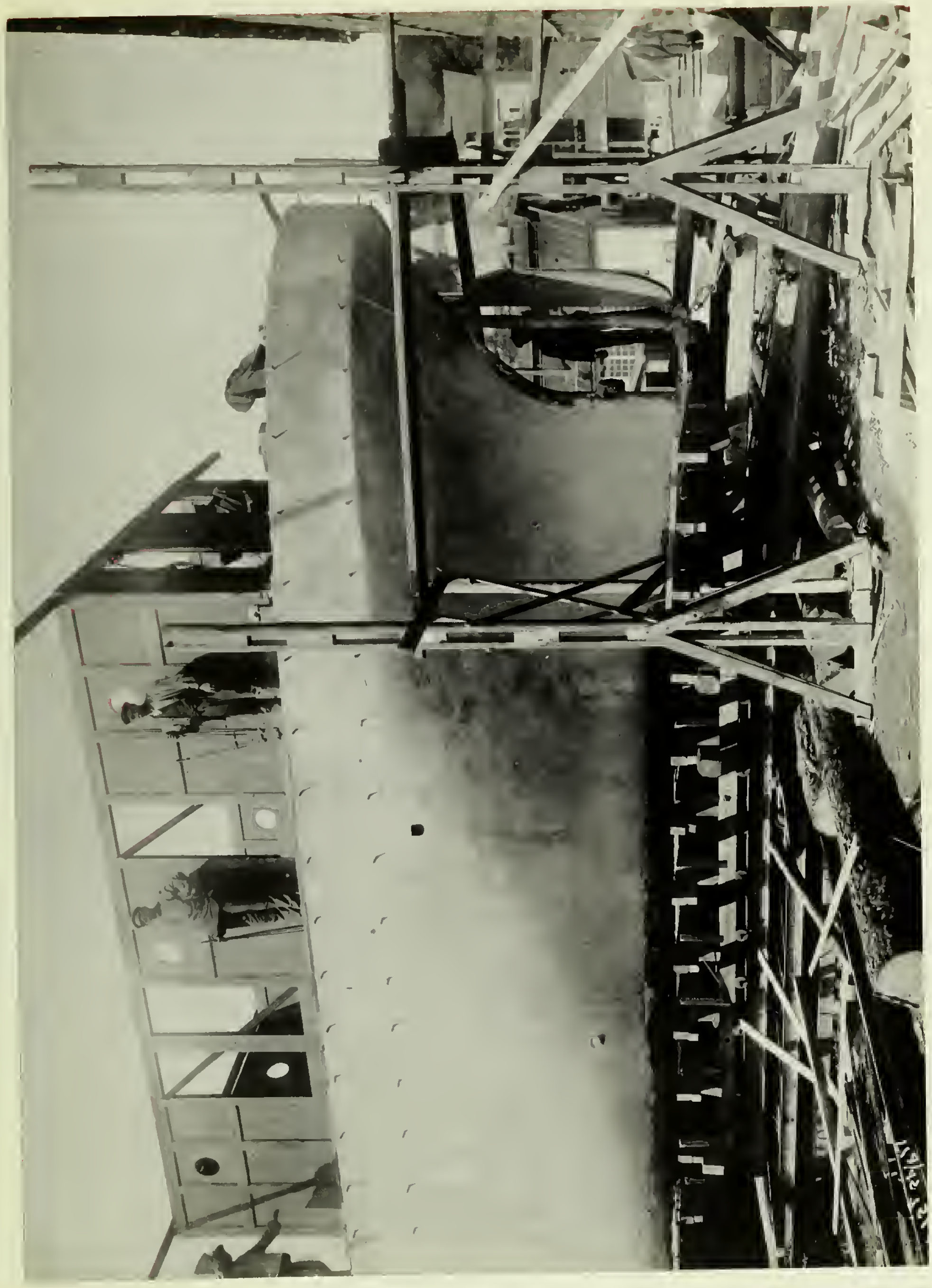


FOUGNER'S "NAMSENFJORD" ON HER WAYS

In a late report the American Consul-General at Christiana describes the plan of the shipbuilding concern



BOW VIEW OF "NAMSENFJORD" ON HER WAYS AND
ALSO OF CONCRETE DRY DOCK



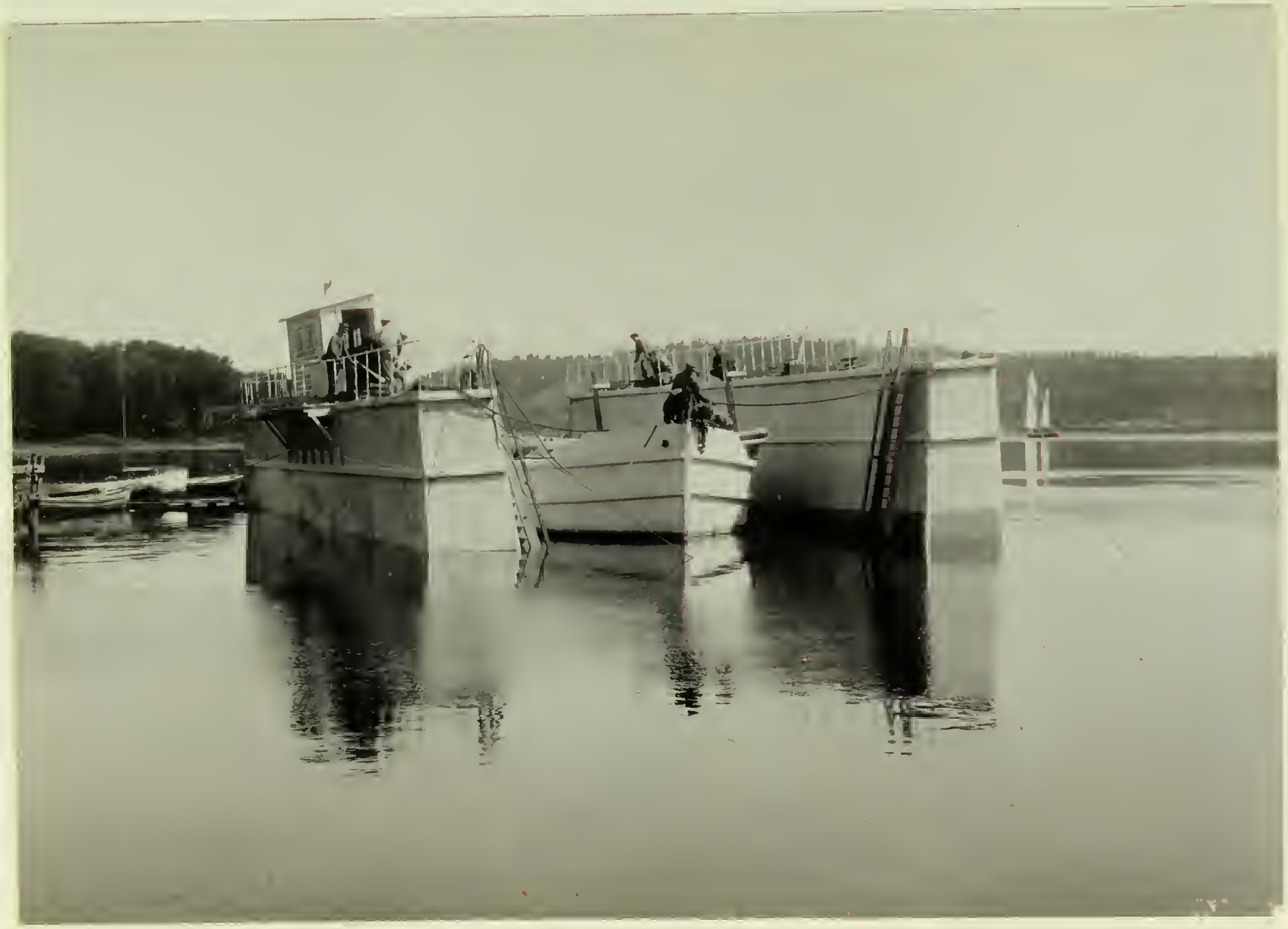
"NAMSENFJORD" A FOUGNER SHIP UNDER CONSTRUCTION

at Moss, Norway, and refers to the construction of 3000-ton concrete boats at this plant. The following, quoted from the report, indicates the extent of the work under way at that time:

"The inventor of this new style of vessel is said to be M. Nicolai Fougner, an engineer, who claims to be able to construct a ship of any size demanded. He is now building a lighter for a mining Company at Sydvaranger for the oversea export of iron ore and the import of coal. The vessel, having a displacement of 3,000-tons, is to be ready before the end of the current year, 1917. It is stated that these concrete ships can be sailed or engined like other vessels, and experts consider that a new epoch in shipbuilding has arrived.

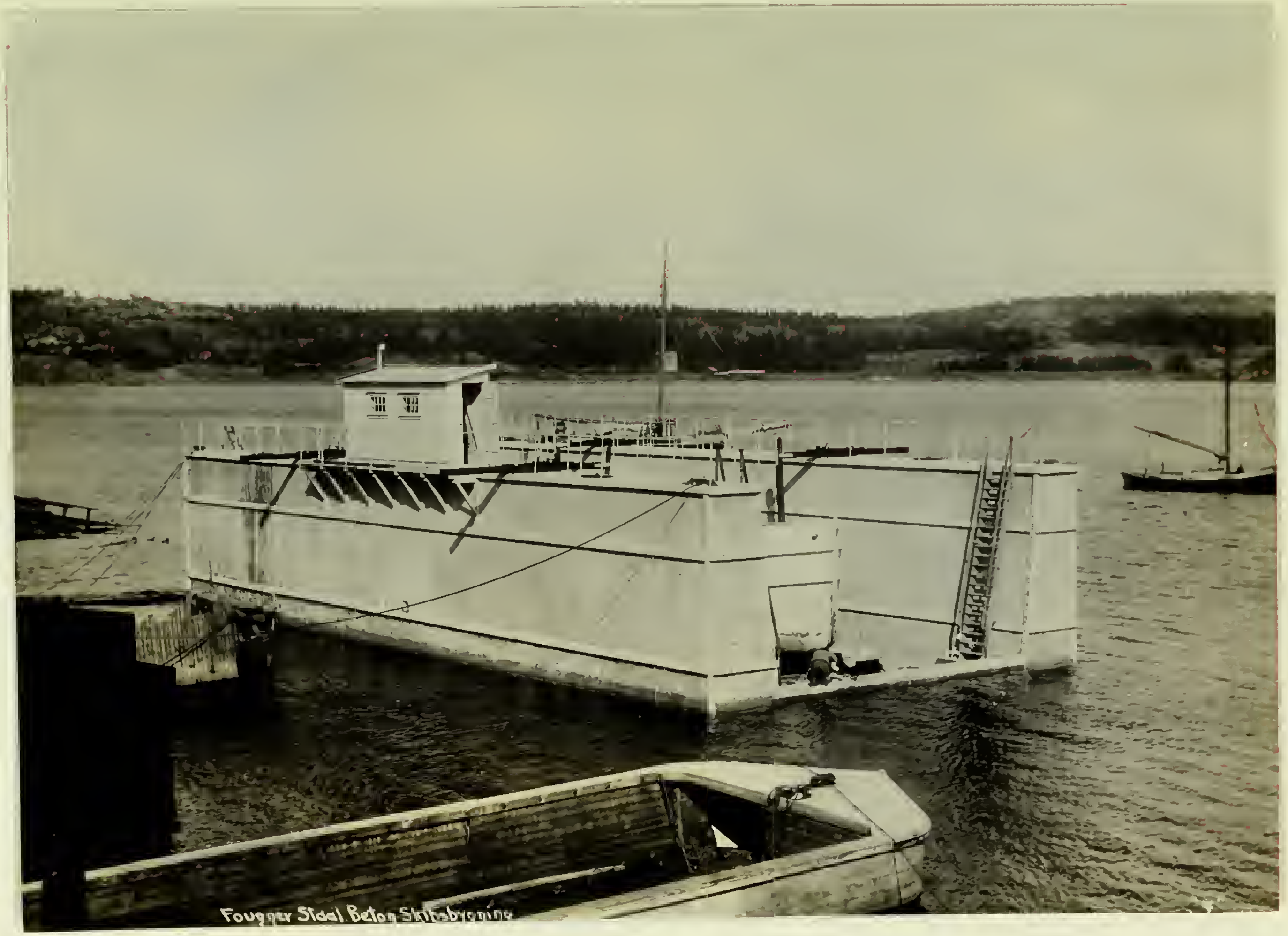
"The ship which arrived in Christiana last month, resembles a large barge and is constructed entirely of concrete with the exception of the ribs, which are of steel. This new method of constructing ships has attracted much attention. The Swedish Minister of Marime, M. Brostorm, one of Sweden's largest shipowners, immediately ordered a lighter of some thousand tons displacement and he was present when the craft was launched at Moss. He was accompanied by four experts all of whom expressed much satisfaction at the result.

"Two other lighters are now on the stocks and a large slip for a 4,000-ton craft is nearly completed. More than 200-men are now working in the new yards, and five lighters have been contracted for in addition to the one completed

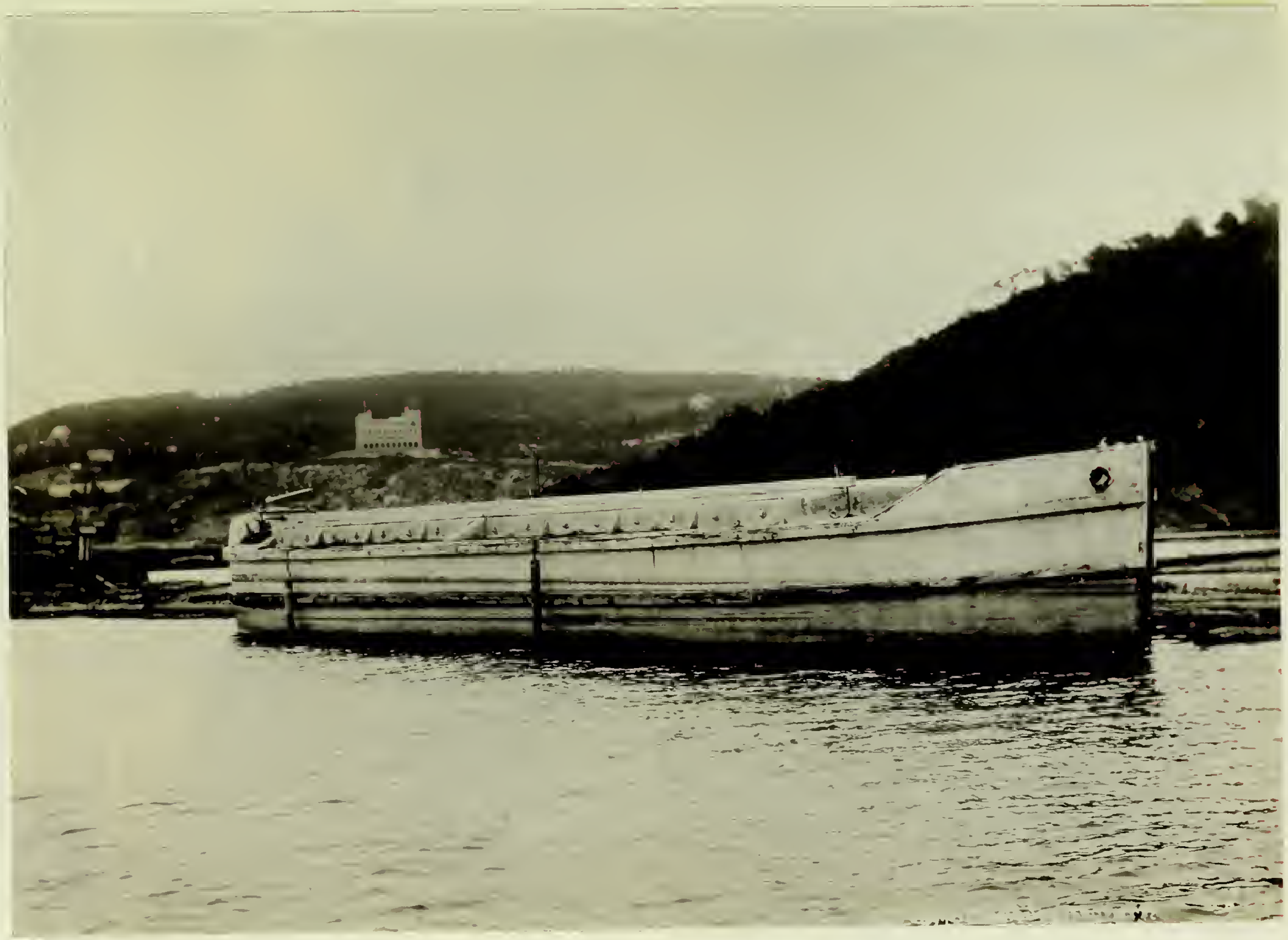


REINFORCED CONCRETE DRY-DOCK OF FOUGNER DESIGN
AND CONSTRUCTION, DOCKING A REINFORCED CONCRETE VESSEL

[illegible] 14



FOUGNER DRY DOCK WITH CONCRETE BARGE IN FOREGROUND



A FOUGNER BARGE WITH MORE HIGHLY DEVELOPED SHIP-LINES

and the two on the slips."

Since the foregoing report was written, the following news item has appeared in MOTORSHIP (Seattle) for June 1917:

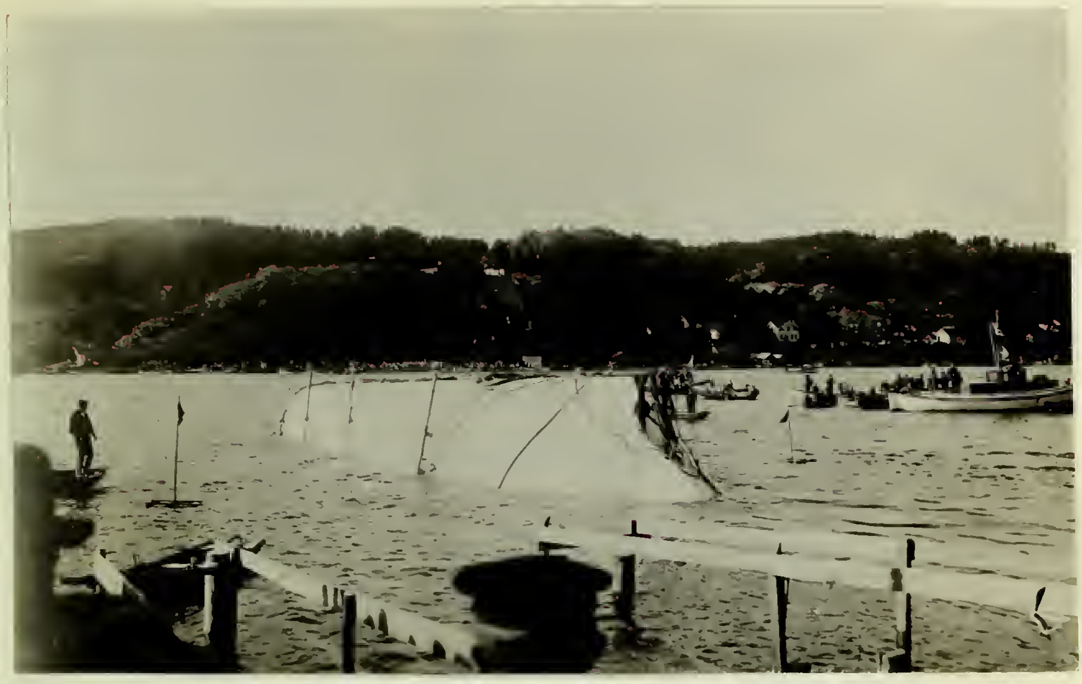
"300-TON DIESEL MOTORSHIP OF FERRO-CONCRETE"

"There is due for delivery in July, the first large motorship of ferro-concrete construction, which now is on order for the Sydvaranger Mine Company of Norway, and will be used for carrying iron ore across the North Sea. She is of 3,000-tons and is being equipped with two direct reversible Polar Diesel engines each of 300 b.h.p. Her builders are the Foughners Staalbeton Skilsbygnings Company of Moss, Norway, who will build semi-concrete hulls up to 5,000 tons per ship."

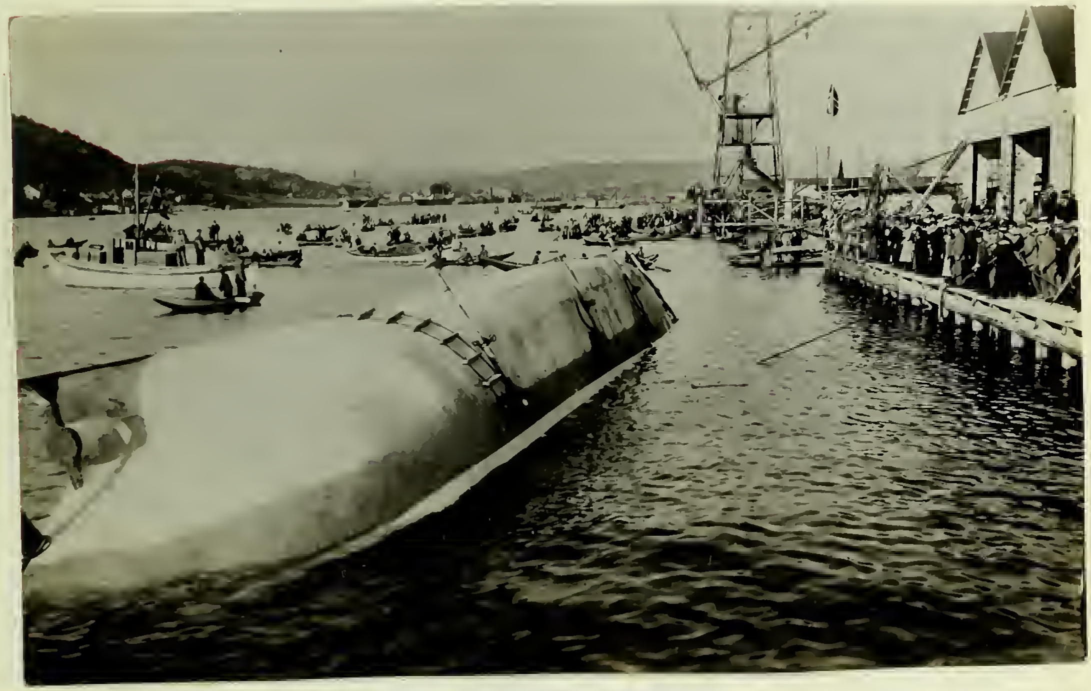
Jens Hauland, Vice President and General Manager of a concrete products plant at Porsgrund,Norway, was in the United States in 1917, exhibiting a 9-foot model of a boat built according to plans that his company is following in constructing concrete vessels of 200-tons capacity. One such vessel that was nearing completion was to be launched early in August. The 9-foot model spoken of was turned over to the United States Bureau of Standards to enable it to study the methods of construction. Mr. Hauland says that companies have been formed in Bergen,Norway;and Buenos Aires, South America, to build concrete vessels after the plans his company is using.

An interesting feature of the method used at Mr.Hauland's plant at Porsgrund,Norway, is that the vessel is built bottom

VIEWS AT PORSGRUND CEMENTSTOEBERI.

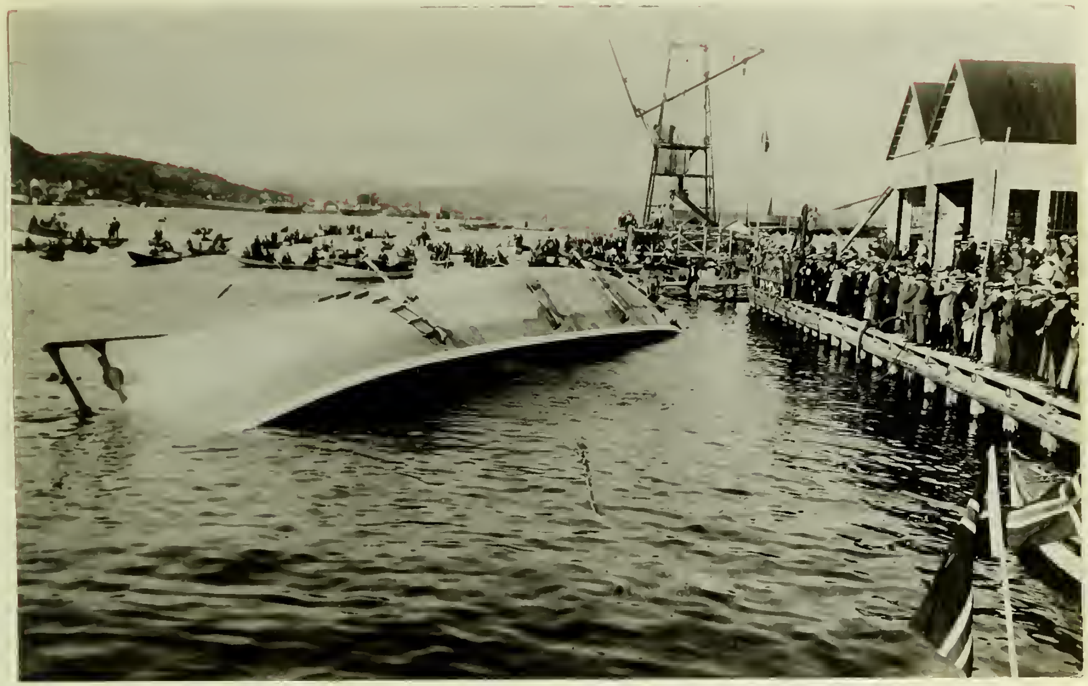


200-TON BARGE IMMEDIATELY AFTER LAUNCHING

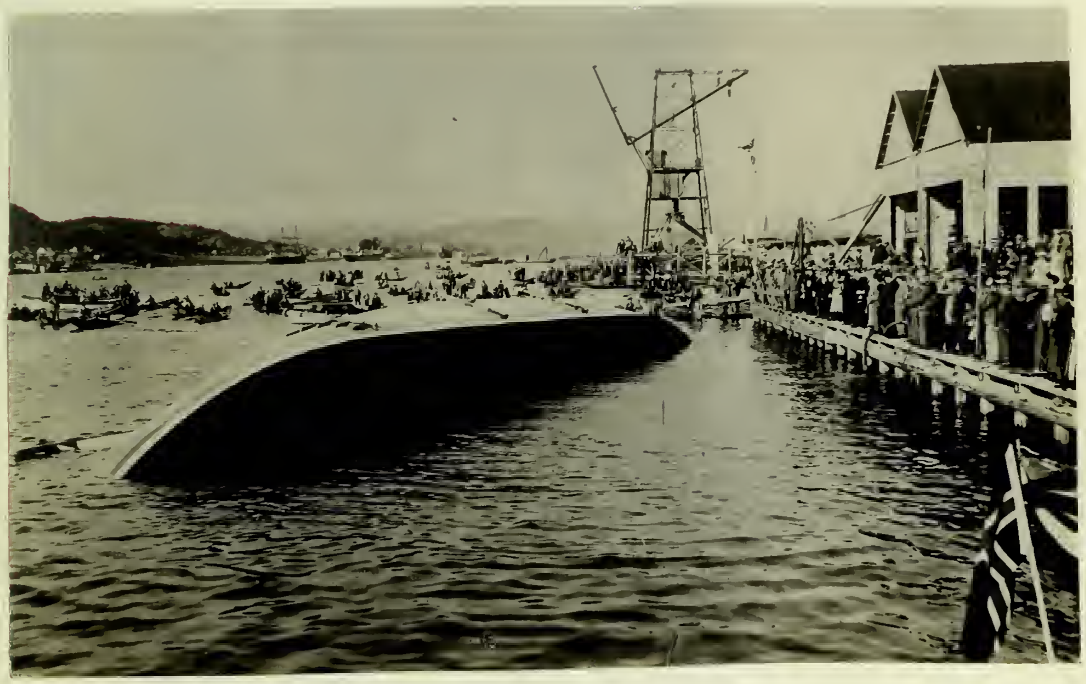


BARGE BEGINNING TO TURN

VIEWS AT PORSGRUND CEMENT STOEBERI

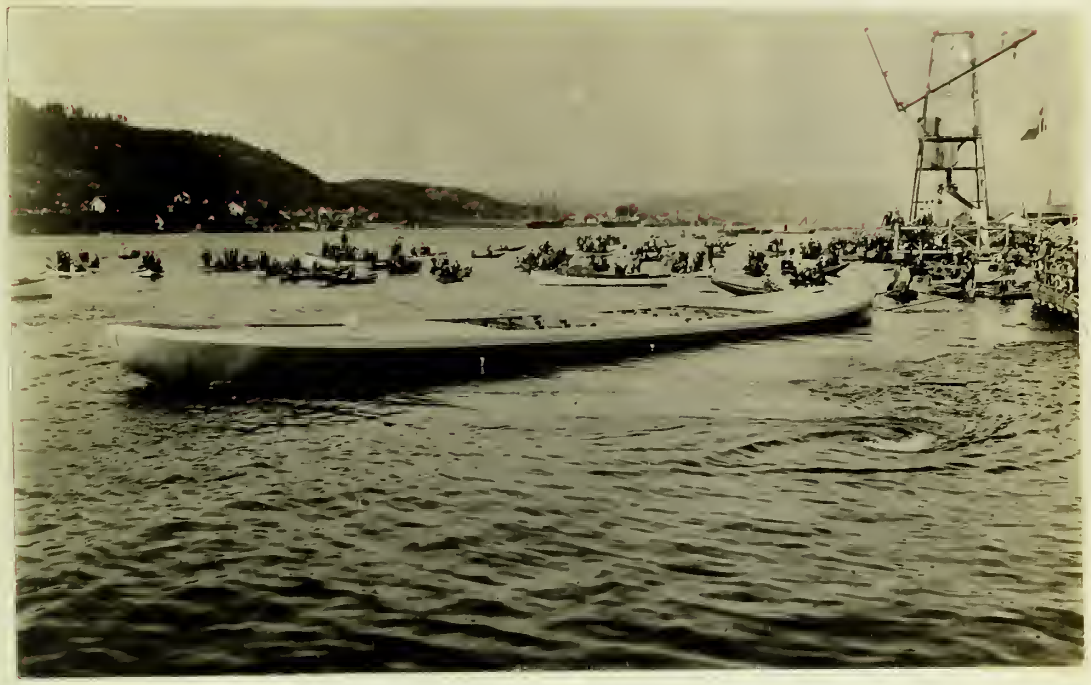


FURTHER TILTING

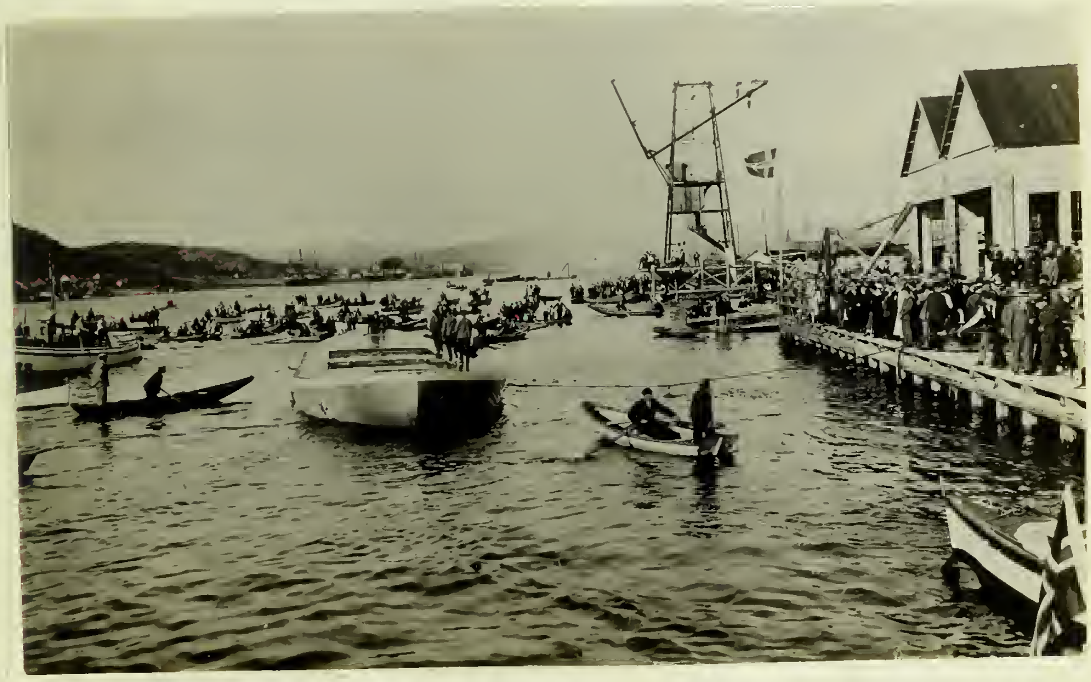


AND SOME MORE

VIEWS AT PORSGRUND CEMENT STOEBERI



JUST TURNED



ALL ABOARD

up, an internal mold being used which is made in units that can easily be taken apart and reassembled. The vessel is launched in the same position in which it is built - bottom up - and by special arrangement of interior compartments that admit a small amount of water, the vessel is self-righting when launched. The general structure of the vessel is a series of transverse ribs with a thin shell and because of the fact that it is cast bottom side up, it is easier to control the density of the concrete along the bottom and lower side of the hull, consequently thinner sections can be used than might otherwise be possible.

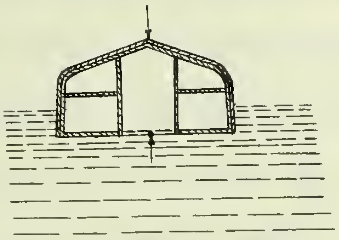


FIG. A

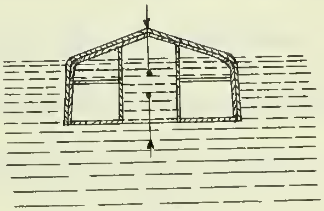


FIG. B

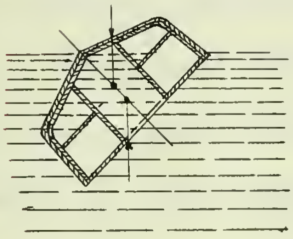


FIG. C

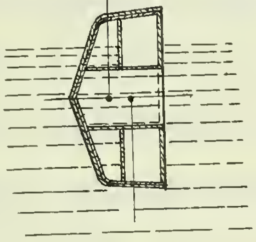


FIG. D

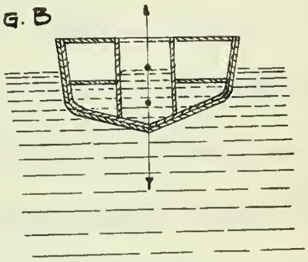


FIG. E

SHIPPING (New York) Of November 3, 1917, illustrated by figures A, B, C, D, and E the principles of launching, which were described as follows:

"The diagram A represents a section of the vessel immediately on taking the water. The inner mold, divided

into compartments is seen, together with the outer reinforced concrete hull of the vessel, and it will be observed that as yet there is no water in the middle compartment of the mold owing to the air not escaping rapidly enough through the vent pipes. As the air escapes, however, the water rises in this compartment, the vessel gradually sinking as it looses buoyancy, until the water reaches the level of the upper side compartments which are also gradually flooded, so that a position is gradually reached as shown at B when the vessel is submerged to its maximum amount. The lower side compartments are never flooded, and thus the vessel is in a state of unstable equilibrium, the center of gravity being considerably higher than the center of buoyancy shown. If now from any cause whatever the vessel heels to one side or the other, the weight of the hull and its contents acting through the center of gravity and the pressure on the submerged area acting through the center of buoyancy, form a couple, the moment of which tends to turn the vessel on a longitudinal axis as shown at C. The moment of this couple has its maximum value when the vessel is in the position shown at D, after which it gets gradually less and less until the vessel floats in the correct position shown at E, when the movement of the couple is again zero, but the vessel is now in a state of stable equilibrium. The slightest list to one side or the other after the vessel has been launched and the compartments filled is thus sufficient to cause her gradually to heel over completely until she floats in a normal position.

The flooded compartments are then pumped out, and the mould is removed, this being used again in the construction of another similar vessel."

Since this article was written the vessel has been successfully launched at Porsgrund, Norway, and it is understood at present (April, 1918) that a 1000 ton vessel of the same type is under construction and will be ready for service during the present season.

SMALLER CONCRETE BOATS IN THE UNITED STATES

"Concrete and Constructional Engineering" (London) reports the construction of a reinforced concrete motor cruiser in 1916, by several members of the Sabin Hill Yacht Club, Dorchester, Massachusetts. The craft is 41 feet over all, with a beam of 8 feet. The following description is taken from the magazine mentioned:

"The framing of the boat is of angle steel and a ten inch steel H-beam forms the keel. Galvanized expanded metal was attached to the framing to hold the concrete, which tapers from one and one-half inches thick at the keel to seven-eights inches thick at the gunwale. At each side at the water line is a sponson, which increases the beam to 11 feet and gives the vessel great buoyancy in a seaway, making her in fact, practically unsinkable. Power for propulsion is derived from a 24 b.h.p. to 30 b.h.p. four cylinder Buffalo engine, which gives a speed of seven and one half knots per

hour. Either petrol or paraffine may be used for running, and the tanks hold 1000 gallons, or enough for a cruise of say, 40 days. Apparatus for developing moving picture films is fitted up in the after cabin while in the main cabin forward special bunks with deep sides for bad weather are provided."

On October 21, 1917, there was presented to the Naval Reserve of Chicago, a concrete motor boat that has an interesting history. Walter Dorsey, who for a number of years lived among the lakes in the north woods near Iron River, Michigan, tried his hand at concrete boat construction. He built a motor boat by using a T-bar for the keel, the end of which was turned upward to form the prow post. Flat steel, 12 gauge by 1 inch was riveted to the ribs lengthwise from prow to stern. Upon this light framework, 1/4 inch square wire mesh was attached to cover the entire hull as a ground work to receive the concrete mixture. This in reality was a cement mortar which was applied with a trowel. The boat is 18 feet 6 inches long with a beam of 4 feet 6 inches, thicknes of hull 3/4 inch, depth of hull 38 inches, and the boat has a 6 horsepower gasoline motor.

Considerable publicity was given to the ceremonies that had been arranged to mark the presentation of Mr. Dorsey'sboat to the Naval Reserve. The boat is now in service (April, 1918) in New York harbor, doing regular work for the Reserve.

CHAPTER III

RECENT CONCRETE SHIPS

Concrete ship builders, convinced of the feasibility of concrete by the smaller vessels, are turning now to the ocean-going type. This is naturally the result of the tremendous demand for bottoms that has arisen on account of war conditions. Apparently, they are willing to risk unknown stresses supposedly developed by heavy seas as they are constructing ships of dimensions never attempted heretofore.

CONCRETE STEAMER BUILDING AT MONTREAL.

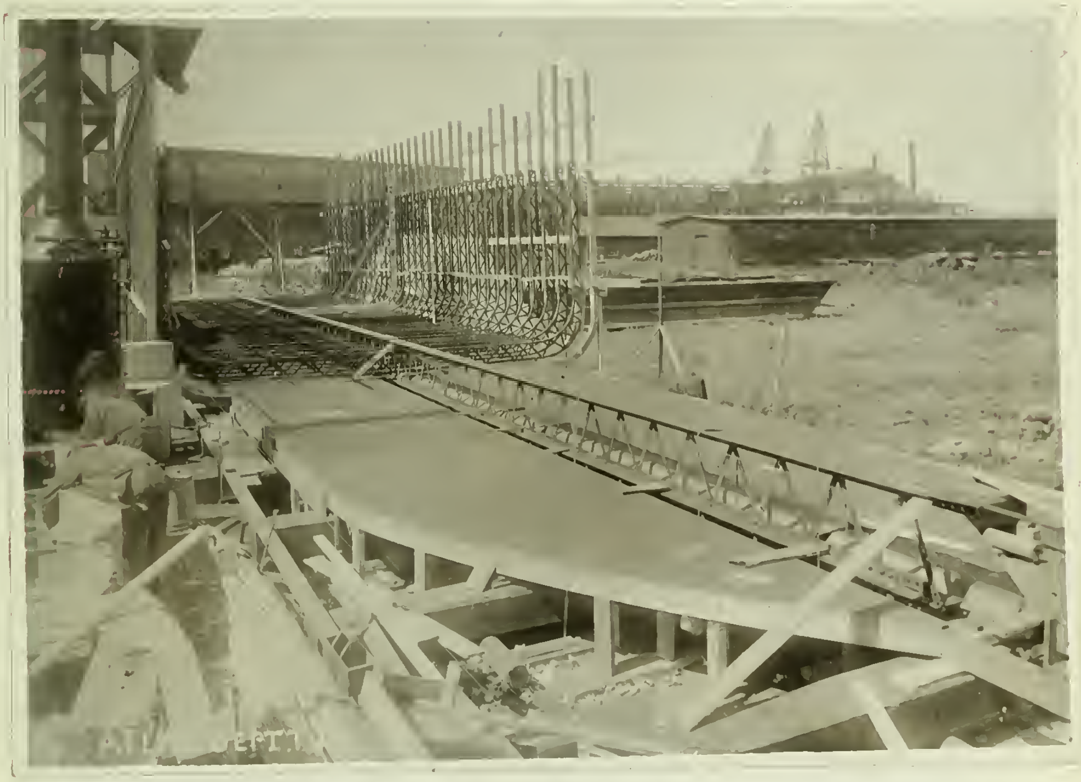
There was launched in November, 1917, at Montreal, a 125-foot single screw steamer that possessed features radically different from those of most other vessels built heretofore. This vessel was built by the Atlas Construction Company, Ltd., of Montreal, that used a structural steel framing upon which a reinforced concrete hull was placed. This vessel has a beam of 22 ft. and a depth of 13 ft. The concrete shell varies in thickness from three to five inches between ribs, which are 27-inches apart.

Use of structural steel members suggest the possibility of lightening concrete ships by means of frame work of another material which is not so exposed to the deteriorative action of the elements as is the hull. This construction permits the use of those structural steel shapes that are obtainable at present, thus doing without plates for which demand is greatest. It is possible that some of the present difficulties of design

may be overcome by this quick and simple method of construction.

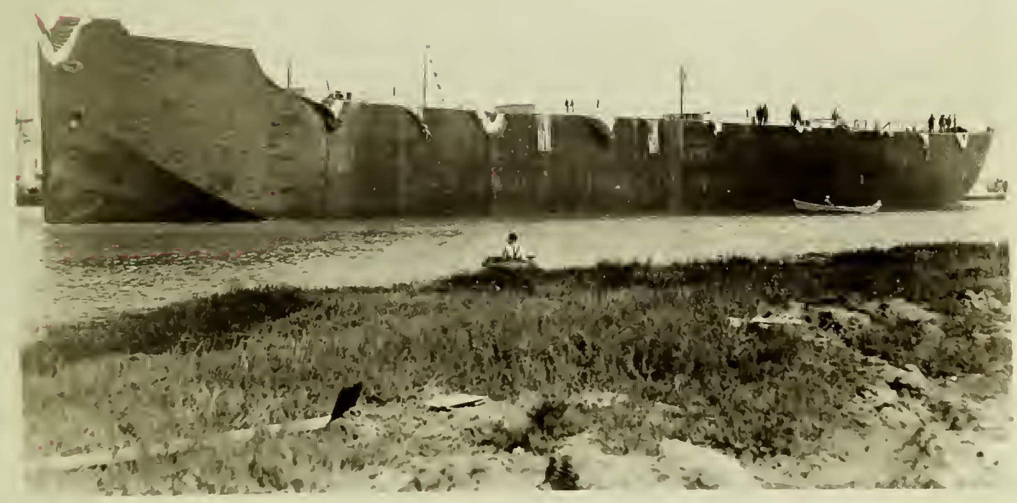
"SAN FRANCISCO" SHIP

Early in 1917 a group of San Francisco capitalists formed the San Francisco Ship Building Company, to undertake the construction of sea-going vessels of concrete. The first ship they started was launched in March 1918 and is a 4500 ton vessel, 330 ft. long with a 46 ft. beam. In this ship reinforced concrete sections were used throughout, so that really it may be called the first large ship using a reinforced concrete design.



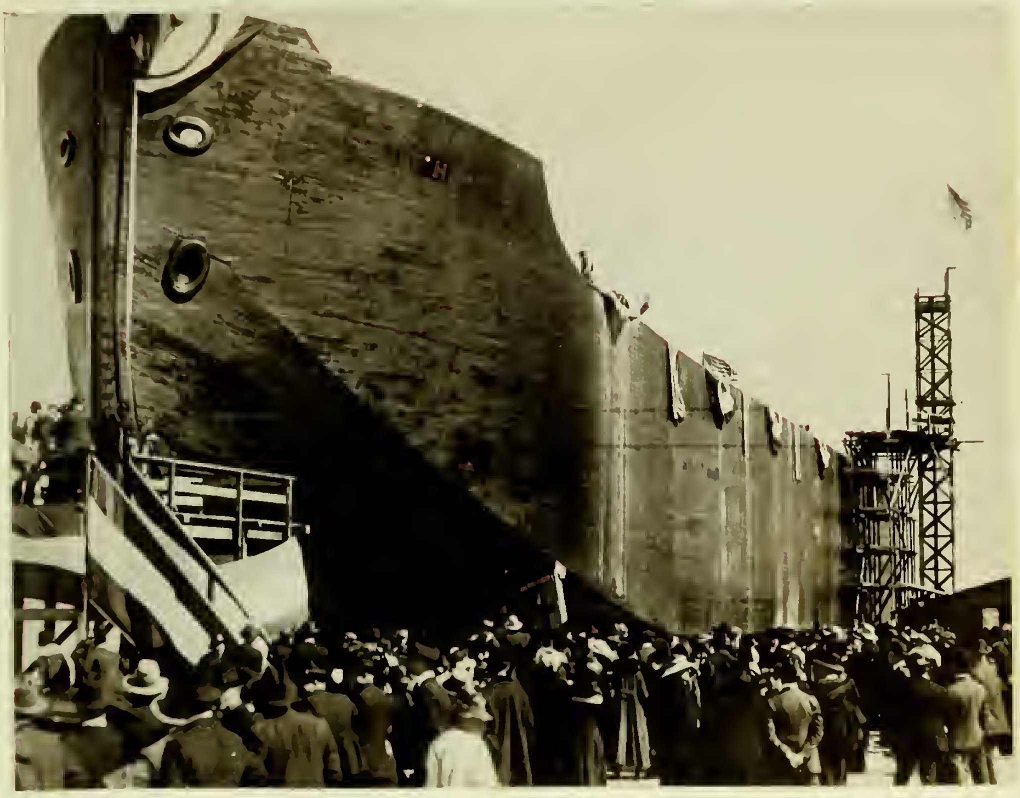
STRUCTURAL STEEL FRAMES AND KEEL OF MONTREAL SHIP

Construction of the vessel took place at Redwood City, California, and was remarkable because of the small plant required. A meadow, on which a concrete plant was erected, together with a set of launching ways were all that was required. The hull and frames were constructed by erecting the reinforcing system, building up forms and then pouring concrete into place. Ninety days after concrete had been placed the ship was in the water.

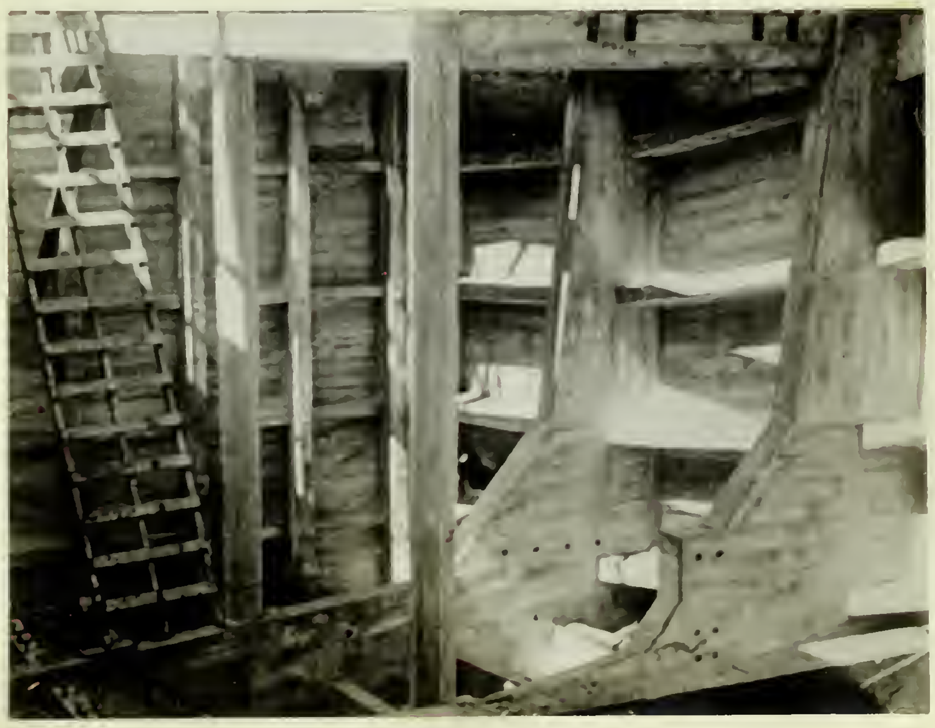


NOTE THE ANGULAR BOW-LINES

"FAITH" BUILT BY SAN FRANCISCO SHIPBUILDING COMPANY



READY FOR LAUNCHING



VIEW OF INTERCOSTALS AND FRAMES

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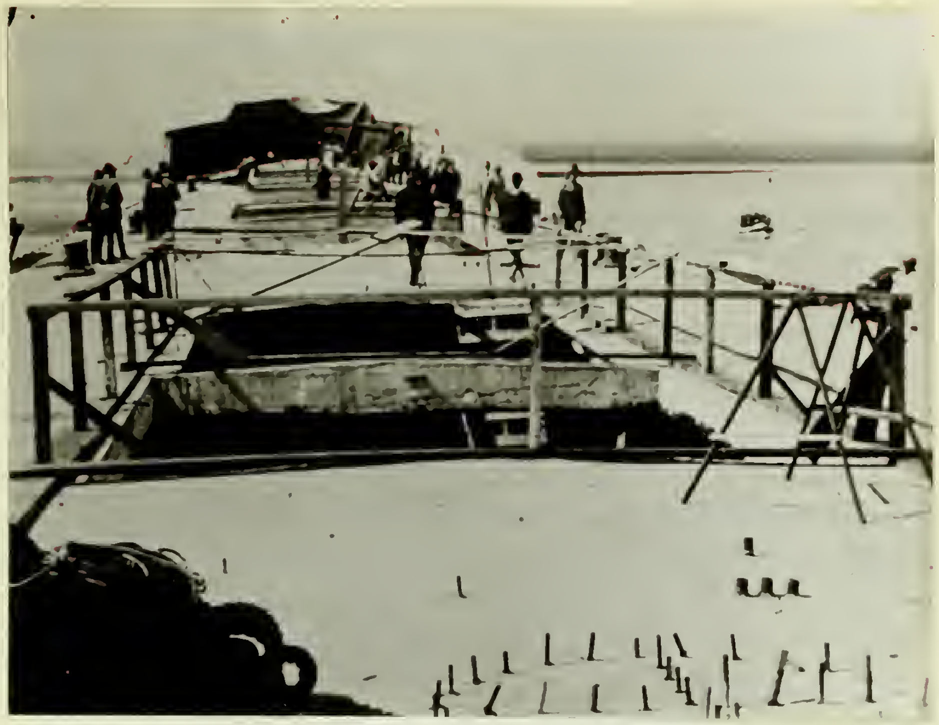
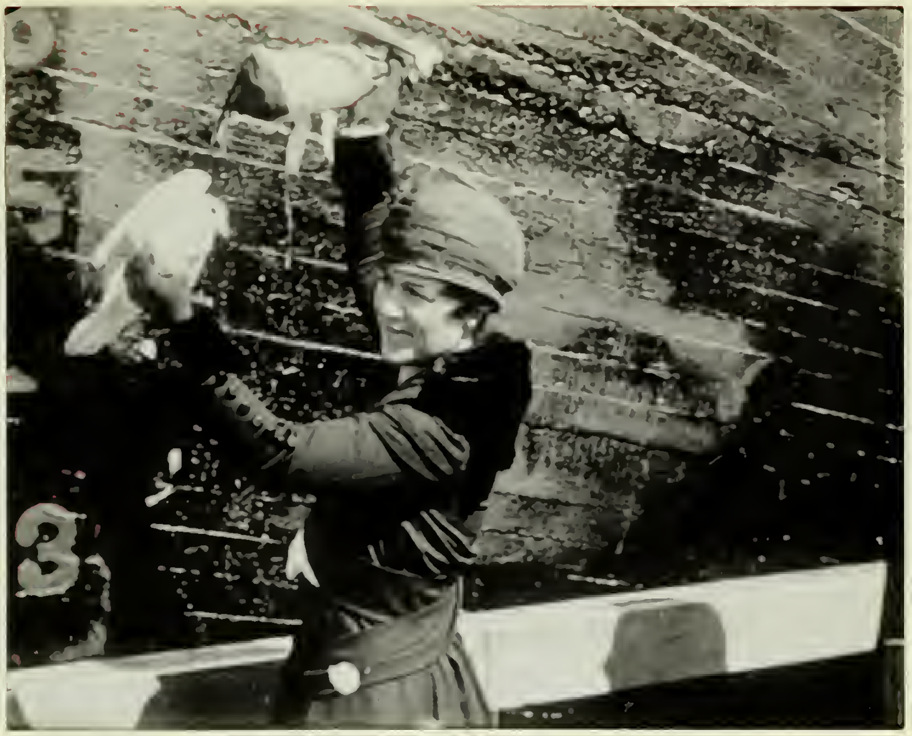
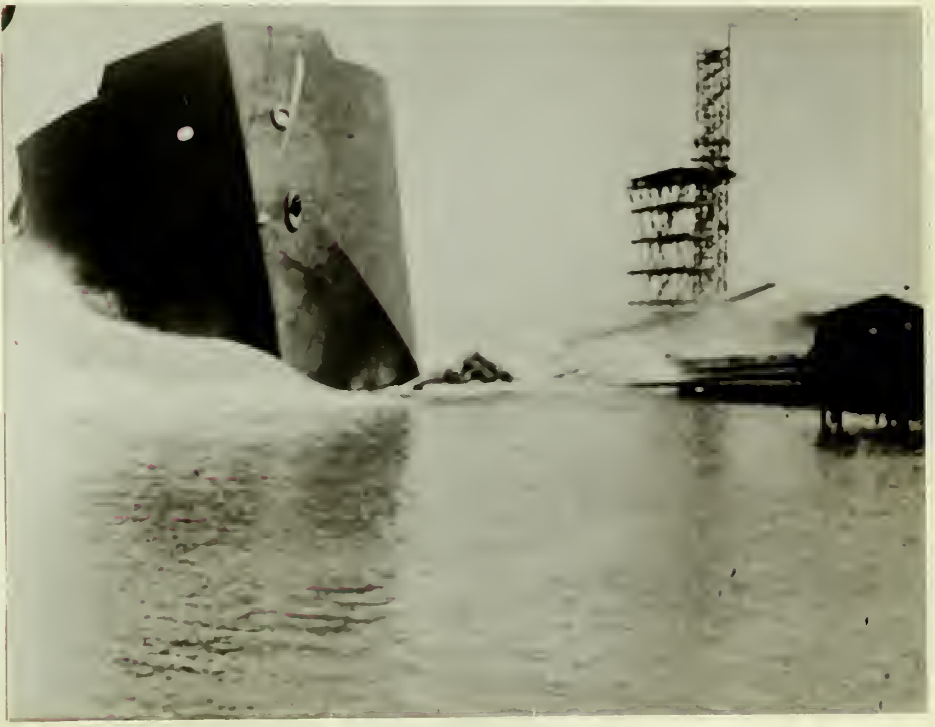
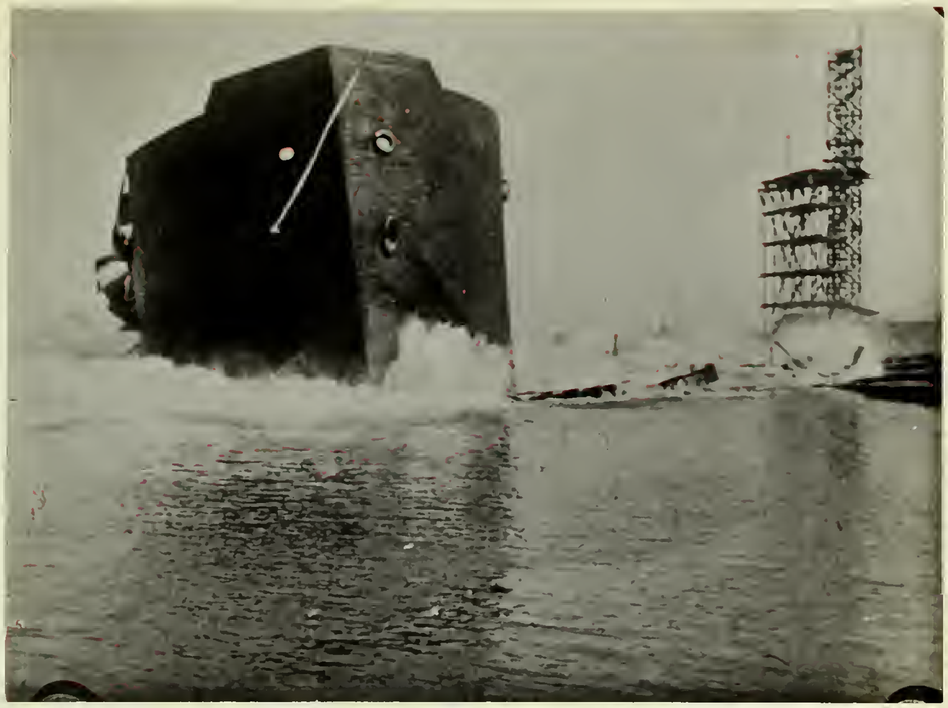


SCENES ON DECK OF "FAITH" PRIOR TO LAUNCHING

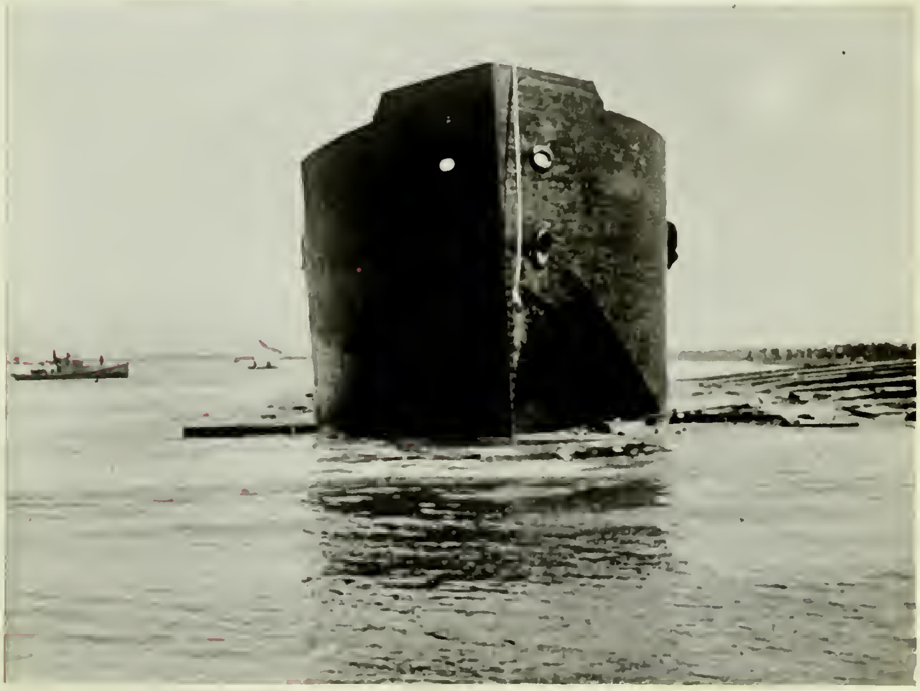


LAUNCHING OF "FAITH"





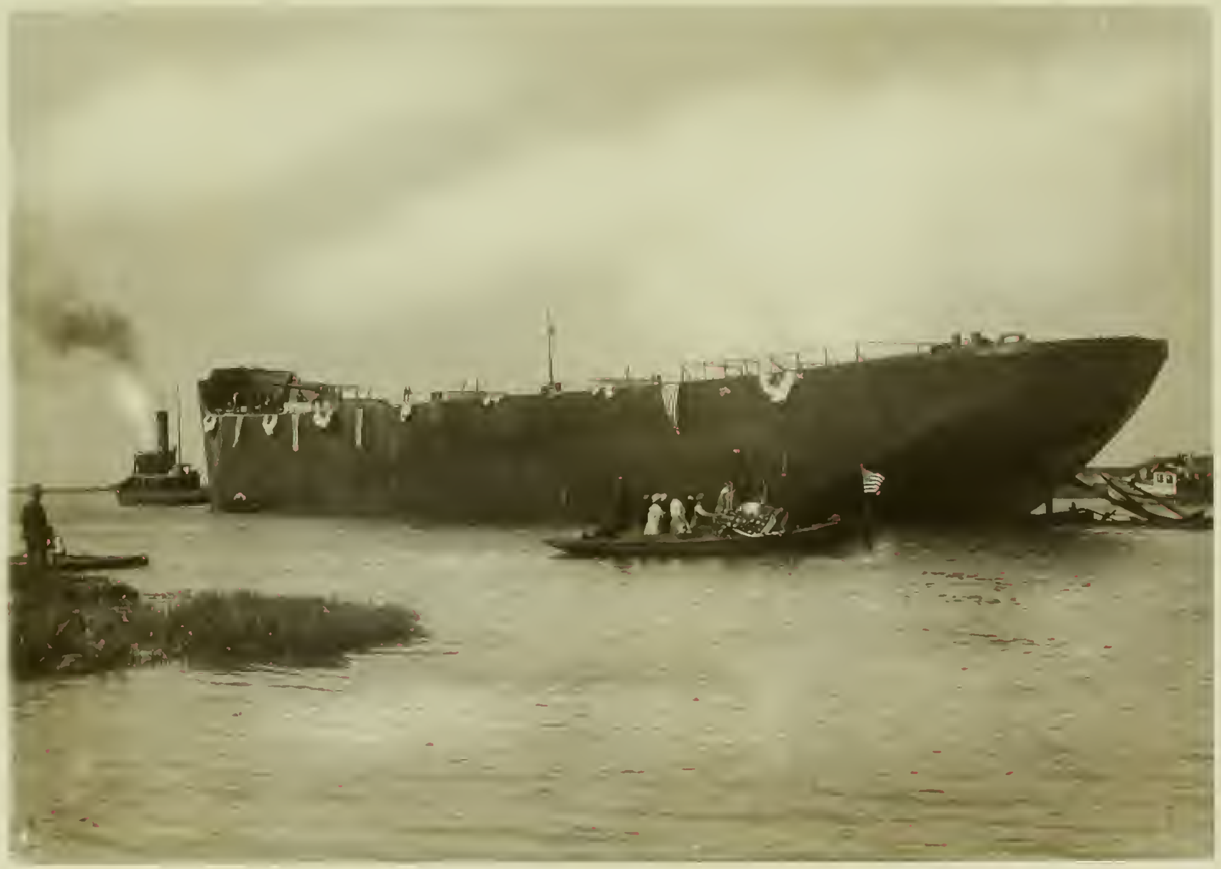
LAUNCHING OF"FAITH"



[illegible]

Very little information is obtainable regarding the fundamentals upon which the design is based. It is said that this company had considerable difficulties with their engineering forces, which may account for their reticence. At any rate, so far no information has been permitted to leak out which would be of value to the marine architect who contemplated building reinforced concrete vessels. Pictures of the reinforcing indicate that a very high percentage of steel was used and that this was placed diagonally in both directions and also transversely. Evidently the diagonal bars were intended for the purpose of transmitting the shearing stresses and, at the same time, acting as a reinforcing for the negative and positive moments developed between intercostals.

It was first intended to tow the hull to Honolulu and back to San Francisco for the purpose of determining its strength, but after launching the builders decided that the needs for bottoms were so great that it was feasible to install the propelling machinery immediately. Reports from the Coast state that this is going on rapidly and that by the middle of May, 1918, the work of equipping the vessel should be completed. Internal combustion engines are to be used and the ship provided with sufficient power to drive it at a speed of ten knots per hour. A view of the bow of the ship might cause some misgiving regarding its low water resistance, since the angular projection seems unnecessary at this point. The low speed at which it is intended to drive the vessel will hardly be affected by this irregularity of the hull, however,



"FAITH" IN TOW AFTER BEING LAUNCHED

since only at much higher speeds does this become noticeable.

The successful launching of this vessel has not alone given its construction of concrete wide publicity, but it has also resulted in producing an added confidence among those who heretofore believed in the successful application of this material in larger ships. though they had nothing upon which to base their belief.

CARL WEBER METHOD OF SHIP CONSTRUCTION

Contracts for two oil tankers to be built by the method proposed by Carl Weber, a well-known concrete engineer and former president of the Cement Gun Construction Company of Chicago, have been made by the Torcrete Shipbuilding Company, of which Mr. Weber is now president. There is no available information at present regarding the exact sizes of these vessels, but it is generally understood that they are to be similar to the 3500 ton Emergency Fleet Corporation design. Mr. Weber's method possesses considerable merit and deserves further description which, briefly summarized, is as follows:

First: - A skeleton of structural steel with members running transversely and longitudinally throughout the hull.

Second:- A system of reinforcing steel rods supported by the skeleton.

Third: - A layer of wire mesh or expanded metal placed outside the steel rods.

Fourth:- A shell in which the concrete is placed by a mechanical process, embedding the reinforcement.

Mr. Weber's method possesses several advantages. In the first place no heavy and therefore expensive form work is required, since the concrete is shot in place by means of a machine which he calls the "Tector". This requires only a light inside form sufficient to take the impact of the first layer of concrete; thereafter successive layers are shot in place until the completed hull has a uniform surface. Recent tests on slabs made by this process indicate very high compressive values of the concrete and therefore give promise of the successful application of concrete in this manner.

CHAPTER IV

REVIEW OF CONCRETE SHIP SITUATION

Development in concrete ship design, though speeded up by war, has in the main been quite satisfactory when compared with that of vessels built of other materials. When we remember that seventy years ago the first row boat of reinforced concrete was constructed and that today there is floating on the water a 4500-ton vessel, concrete builders can proudly point to their achievement and ask critics what other material has had an equally rapid development.

Study of the design of steel and wooden vessels will reveal the fact that progress in this case was not very rapid. When wooden ships were first built, mathematics was classed as an abstract science and few so-called engineers knew how to apply it. Ship design was therefore developed almost entirely by rule of thumb. By the time steel was brought to use, the engineering sciences had been more highly developed, but in spite of this the older method of "cut and try" was employed and today we find examples such as is illustrated by a recent description in the Chicago Daily Tribune of one of one of our destroyers, which after its initial trip had stiffener angles added to the deck plates because they had been damaged by wave action.

Due to the non-plastic character of wood and steel, ship shapes and construction methods have remained very similar to one another. In concrete, on the other hand, many novel schemes are possible. The idea of launching a ship "upside down" as done by the Norwegians,, is an illustration of this, although its application is questionable in the case of larger vessels. Carl Weber proposes a process that gives promise of great reduction in form costs, which should increase the economy of concrete vessels to a great extent. Reduction of motive power may also be looked for in concrete ships because better shapes and smoother hulls may be developed that will make this possible.

It has been suggested that concrete vessels may be constructed and floated in a period of six weeks to two months when built in a dry dock or lifting dock. If this proves more practical than the old launching method, a change in the time-honored custom surrounding the christening of a vessel may be anticipated. Professor Sadler of the University of Michigan, however, suggests that launching strains are the least of a ship's difficulties and therefore the economy of the new method is doubtful.

Out patent offices are filled with schemes for constructing concrete vessels. Generally these possess but little merit, since they have frequently been developed by men unfamiliar with engineering practices. This suggests that in the design and construction of concrete vessels only experienced concrete builders should try their hand, since the failure

of a ship, due to ignorance, might easily be interpreted as resulting from an inherent defect in the material.

If concrete vessels are to be successful, careful workmanship, skilled supervision and painstaking design are absolutely essential. The character of some of the men engaged in this work at present gives encouragement in this respect, however, and it is to be hoped that their efforts will result in a successful demonstration of the practicability of concrete ships.

CONCLUSION

To define the problems of concrete ship builders and designers in an exact manner is difficult. At present we know, however, that investigation along various lines is essential and this may be outlined as follows:

Shear - High shearing values of wood and steel when compared with their tensile values have previously made this factor negligible. Vessels have not failed because of shear and the subject has been given but little attention. In the case of concrete this is quite different. Were a ship constructed with sides of sufficient thickness to take full shear when computed according to ordinary practice or even using higher values, such as 200 pounds per square inch, the weight would make the vessel too heavy. To overcome this, various methods of reinforcing are employed. In some the shear is taken care of by diagonal reinforcing steel. Others have assumed more than ordinary values for steel and concrete and have also included large portions of the top and bottom surfaces. In all these, actual test data were lacking and investigations should most certainly be made.

Frame design - The computation of rigid frames in a ship by any method, such as the slope-deflection or method of least work, gives results that are positive in their way, but additional test data should be made available on the actual stress conditions at the joints.

Percentage of Reinforcement - Concrete ship design

requires higher percentages of reinforcement than has been commonly used heretofore. Further investigations of this subject, both with reference to the actual distribution of stresses where percentages are high and also the transmission of stresses between members running diagonally to one another should not be overlooked by our laboratory experts.

Moduli of Elasticity - In any method of computing rigid frames, a uniform modulus of elasticity must be assumed, but as concrete is not a homogeneous substance, the effect of this should be investigated. Further assurances, by means of tests, as to the correctness of transforming steel values into concrete for use in rigid frame design, would be of value, or otherwise if this data exists, the same should be prepared in an available form for distribution.

Correlated with the investigation for moduli of elasticity of reinforced concrete sections, there is the important question of stress distribution. All investigators should bear in mind that not only is it necessary to be certain that the structure is strong enough but its exact strength must be determined as closely as possible since every pound of weight counts.

It is to be hoped that this thesis may be of benefit to those who are anxious to assist in solving the problems that concrete ships present. A complete exposition of the subject can hardly be expected because of the present state of information existing in the reinforced concrete field. If it has induced any one to go ahead and assist in this work, who has the ability to solve concrete problems, the author will feel well repaid, for he is certain that there is but little published information on the subject that is in such a form as to be readily available to concrete ship builders and designers.

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